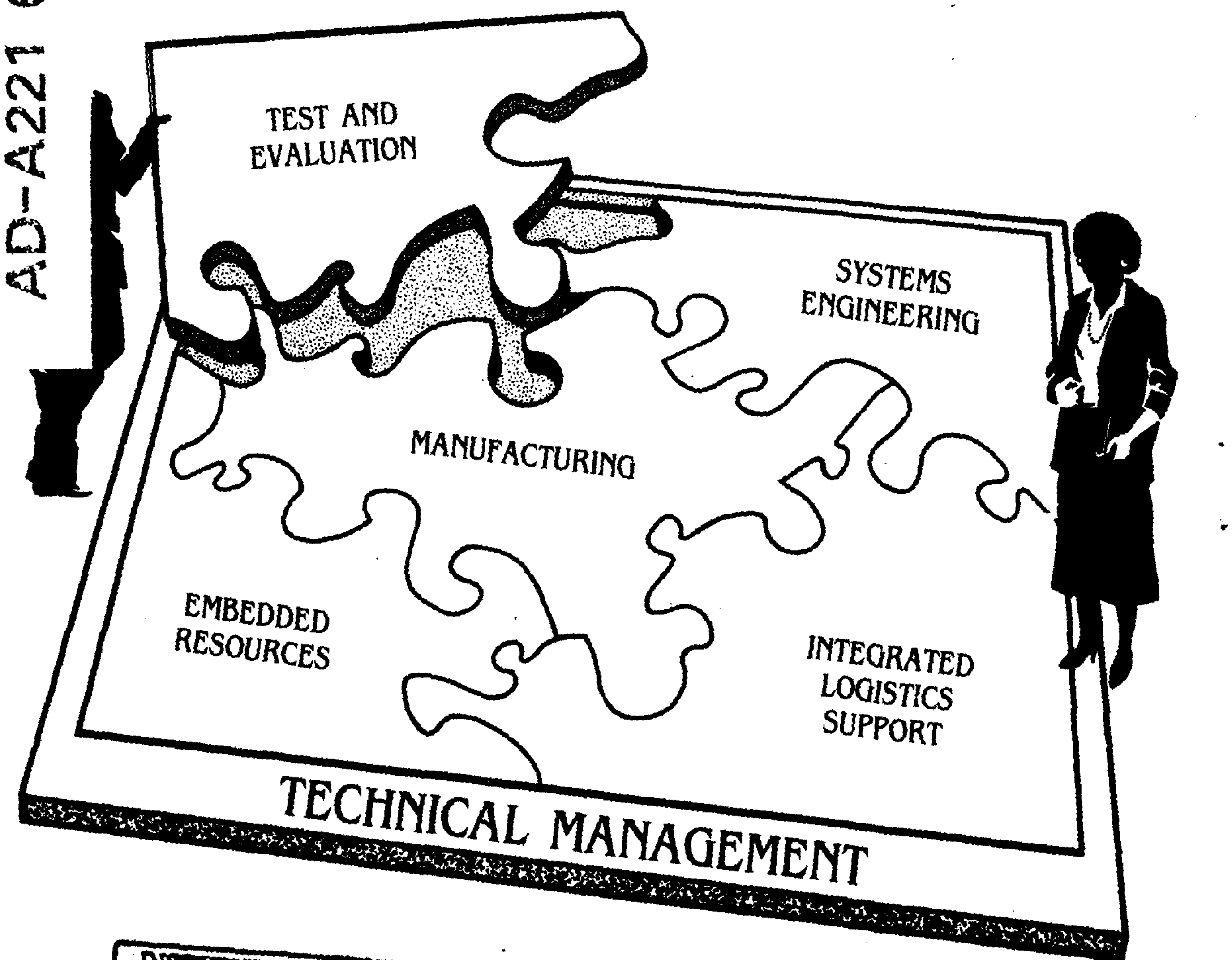
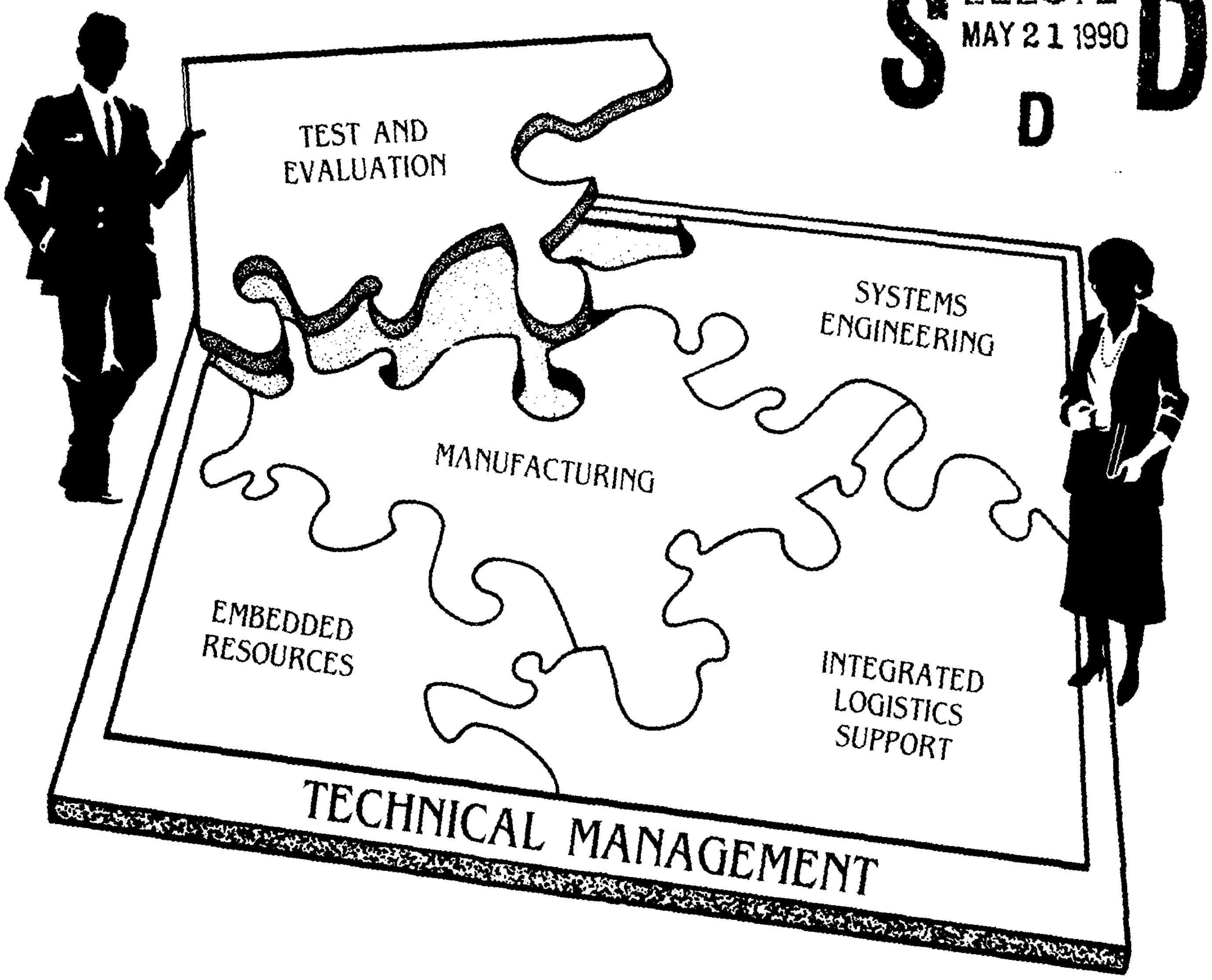
TEST AND EVALUATION MANAGEMENT GUIDE

MARCH 1988



TEST AND EVALUATION MANAGEMENT GUIDE

MARCH 1988



DEFENSE SYSTEMS
MANAGEMENT COLLEGE

FOREWORD

This book is one of a family of educational guides written from a Department of Defense perspective; i.e., non-Service peculiar. They are intended primarily for use in the courses at the Defense Systems Management College (DSMC) Technical Management Department and secondarily as a desk reference for program and project management personnel. These books are written for current and potential Department of Defense (DOD) acquisition management personnel, who have some familiarity with the basic terms and definitions employed in program offices. They are designed to assist both government and industry personnel in executing their management responsibilities relative to the acquisition and support of defense systems. They include:

a. Integrated Logistic Support (ILS) Guide; First Edition; May 1986
b. Embedded Computer Resources (ECR) Guide; estimated publication date: 1988
c. Systems Engineering Management Guide; December 1986
d. Department of Defense Manufacturing Management Handbook for Program Managers; Second Edition; July 1984.

This family of books is especially needed at this time. The Government desires capable, producible, supportable, testable systems to be brought in within cost and schedule. The increasing cost and technical complexity of defense systems, however, has forced greater specialization of functions and the rise of many specific (and very often vocal) disciplines. Public attention to the Defense Acquisition Process has also intensified. The key to a successful program is intelligent integration and balance among the many disciplines that constitute a modern system. This is achieved through a process that begins with communication among different disciplines and continues with a careful tradeoff process throughout the system life cycle.

Each of the books has a common foreword designed to assist managers in sharpening their judgement and focusing their thinking. They are not to be used as an all inclusive checklist or model of the single correct approach to system acquisition management, because all programs are unique and must be executed with professional judgement and common sense.

This book was developed by THE BDM CORPORATION under contract MDA 903-87-C-0046, directed by DSMC. Special thanks are due members of the The BDM Corporation staff, DSMC faculty, students, alumni, and members of the acquisition community at large, whose comments, suggestions, and materials were helpful in completing this project. The Defense Systems

Management College is the controlling agency for this book. Comments and recommendations relating to the text are solicited. You are encouraged to place them on one of the pre-addressed tear sheets located at the back of the book and mail them to us.

This introduction offers a systems perspective for the technical management of a specific discipline during the system life cycle. Subsequent material in this book provides a guide for managing specific discipline within this broad scope of technical activities. The past several decades have seen the rise of large, highly interactive defense systems that are often on the forward edge of technology. These systems have a natural process of evolution, or life cycle, in which actions taken or avoided in the very early stages can mean the difference between success and failure downstream.

The system life cycle consists of the interval from program initiation to system disposal. All activity in the acquisition process centers around the system/equipment. Thus, the state of definition of the system configuration at any time in the system life cycle is an area of common interest among all disciplines. Phases in the defense system's life cycle are concept exploration/definition concept, demonstration/validation, full scale development, full-rate production/deployment, and operational and support.

The division of technical activities into functional areas of design, test, manufacturing, and logistic support is convenient and usually results in a corresponding division of labor in a program office. As can be seen from Figure 1-1, each of these functional areas is active in the earliest phase of the life cycle and continues through most of the program. The general thrust of technical management is :

- **Define** what it takes to support, produce, and test the system utilizing analyses. Then see if we can afford it.
- **Influence the design** through producibility engineering, logistics analysis, testability design, and design to cost. Develop specifications and translate requirements to contract language.
- **Prepare to execute** by arranging for the test facilities, acquiring and setting up the production line, and designing and acquiring the logistic support.
- **Execute** by testing, manufacturing, supporting.

Figure F-1 is a rigorous endeavor to show technical management activities in relative time phase. As such, it identifies activities that should be accomplished and integrated in the various program phases.

Acquisition of a system is a process that begins with the identification of a need. The goal of a system acquisition is to deploy (in a timely manner) and sustain an effective system that satisfies the need at an affordable cost.

Thus, the effort involved in the acquisition process can be modeled as an input, process, and output. The output is the system. The input is the need and other appropriate constraints. The process consists of managing the technical activities by establishing and maintaining a balance among cost (the resources required to acquire, produce, operate and support, and dispose of a system), system effectiveness (the degree to which a system can be expected to achieve a set of specific mission requirements), and schedule. Much of the criticism leveled at the DOD results from a perception of imbalance among these factors.

POST SCRIPT

The test and evaluation process for DoD materiel acquisitions is a complex exercise of integrating the data collection necessary to satisfy the Program Manager's information requirements on system performance. When poorly managed, test and evaluation events can generate schedule slips or adverse media exposure leading to intensive OSD and/or Congressional interest in a program's status.

The objective of a well managed test and evaluation program is to provide the Program Manager with timely and accurate information to support his decision making process. This guide has been developed to assist the acquisition community obtain a better understanding of the complexities of test and evaluation.

John Claxton
Course Director
Test and Evaluation Management
Course

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

MODULE I

INTRODUCTION TO TEST AND EVALUATION

This first module introduces the test and evaluation process, describes the relationship of T&E to the defense systems acquisition cycle, and discusses the role of T&E in the overall systems engineering process. The module also defines the different types of T&E used in defense system acquisition programs and introduces frequently used test and evaluation documents. The module concludes with a brief discussion of the use of nondevelopment items in defense system acquisition programs and explores the implications of this use on test and evaluation activities.

CHAPTER 1

THE TEST AND EVALUATION PROCESS

1.1 INTRODUCTION

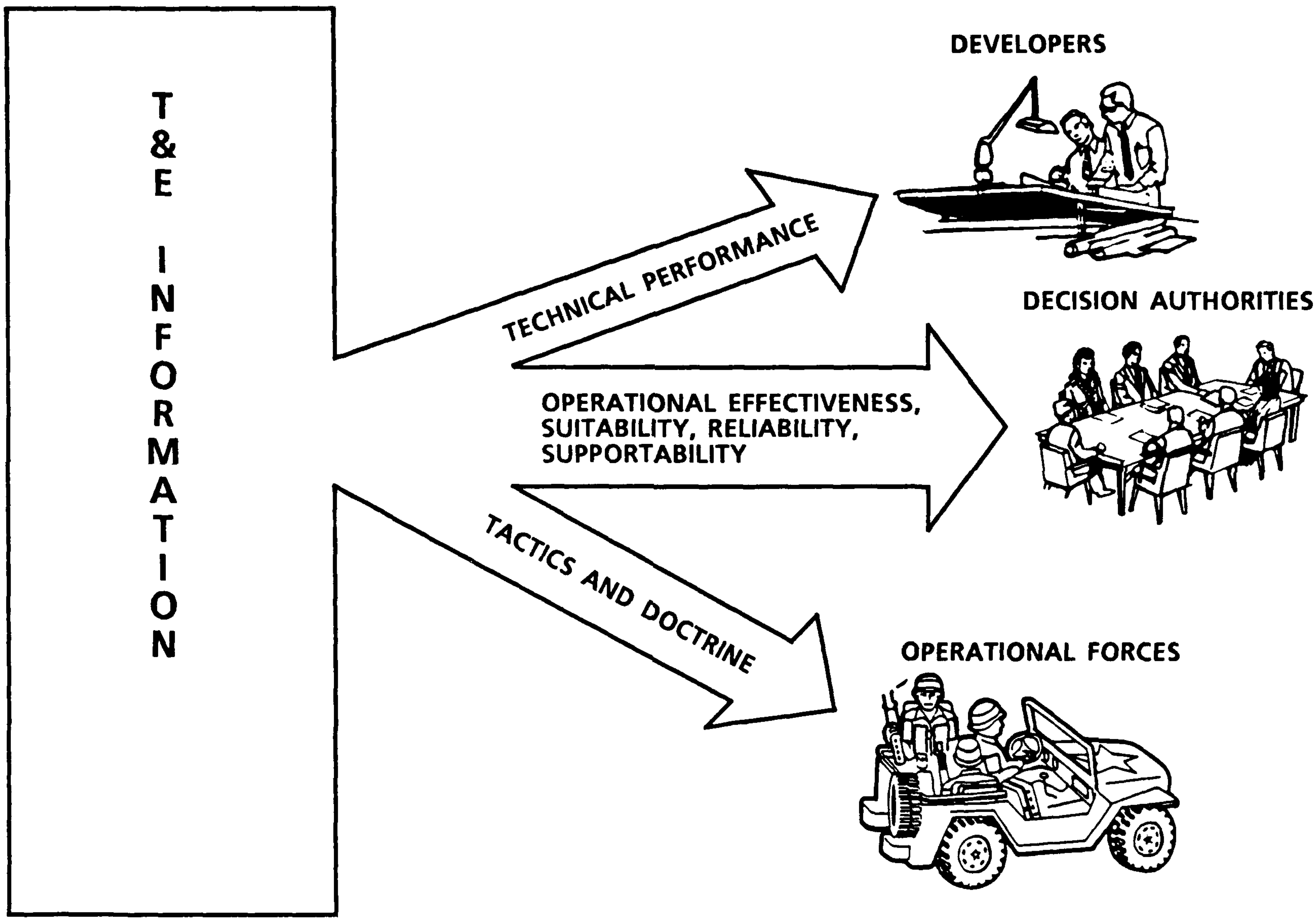
The fundamental purpose of test and evaluation in a defense system's development and acquisition program is to identify the areas of risk to be reduced or eliminated. During the early phases of development, T&E is conducted to demonstrate the feasibility of conceptual approaches, to minimize design risk, to identify design alternatives, to compare and analyze tradeoffs, and to estimate operational effectiveness and suitability. As a system undergoes design and development, the emphasis in testing moves gradually from development test and evaluation (DT&E), which is concerned chiefly with the attainment of engineering design goals, to operational test and evaluation (OT&E), which focuses on questions of operational effectiveness, suitability, and supportability. Although there are usually clearly separate development and operational test events, DT&E and OT&E are not necessarily serial phases in the evolution of a weapon system. In fact, combined and concurrent development and operational testing is encouraged when appropriate (Reference 16).

T&E has its origins in the testing of hardware; this tradition is heavily embedded in its vocabulary and procedures. The advent of software intensive systems has brought with it new challenges and new approaches to testing that are discussed in Chapter 12 of this management guide. What remains constant throughout the T&E process, whether testing hardware or software, is the need for thorough, logical, systematic, and early test planning and the feedback of well documented, unbiased test and evaluation results to system developers, users, and decisionmakers.

Test and evaluation serves a number of useful functions, providing information for a variety of costumers. T&E provides information to developers to assist in the identification and resolution of technical difficulties. T&E provides information to decision makers responsible for making the investment decision to procure a new system and for deciding on the most effective use of limited resources. Moreover, T&E provides information to operational users to support the development of effective tactics, doctrine, and procedures. Figure 1-1 highlights some of the users of T&E information.

1.2 DEFENSE SYSTEM ACQUISITION PROCESS

The defense system acquisition process underwent revision in 1987 in an attempt to make it less costly, less time consuming, and more



*7-1-MCL2-000584-01

Figure 1-1. Users of T&E Information

responsive to the needs of the operational community. As it is now structured, the defense system life cycle consists of the following five phases:

(1) Concept Exploration/Definition
(2) Concept Demonstration/Validation
(3) Full-Scale Development
(4) Full-Rate Production/Deployment
(5) Operational Support

As Figure 1-2 shows, these phases are separated by key decision points (milestones) when a decision authority reviews a program and authorizes it to advance to the next stage in the cycle. T&E results and planned T&E play an important part and are rigorously assessed as part of the milestone review process.

The following brief description of the defense system acquisition process is provided to permit the reader to place test and evaluation within the context of the larger process. The description is based primarily upon information found in DoD Instruction 5000.2 (Reference 16).

1.2.1 Concept Exploration/Definition Phase

The defense system acquisition process begins with the submission of a Mission Need Statement with the Service's Program Objective Memorandum (POM). Secretary of Defense (SECDEF) approval becomes the program initiation decision (Milestone 0). A Concept Exploration Phase follows during which alternative approaches for satisfying the requirement usually in the form of breadboard configurations are investigated. The Concept Exploration Phase concludes with the Milestone I selection of a concept or concepts to enter a Concept Demonstration/Validation Phase. The Milestone I decision establishes broad thresholds for program cost, schedule, and operational effectiveness and suitability. Key documents for the T&E manager at the time of the Milestone I review are the System Concept Paper (SCP), the Test and Evaluation Master Plan (TEMP), and the Integrated Logistics Support Plan (ILSP)/Logistics Support Analysis (LSA). Additional program management documents prepared prior to Milestone I include: the Competitive Prototyping Strategy Document (if required), the Cost and Operational Effectiveness Analysis (COEA) Report, the Common-Use Alternatives Statement, Independent Cost Estimates, and the Program Baseline that summarizes the weapon's functional specifications, performance parameters, and cost and schedule objectives.

1.2.2 Concept Demonstration/Validation Phase

After the Milestone I decision, the program enters the Concept Demonstration/Validation Phase during which selected concepts, typically

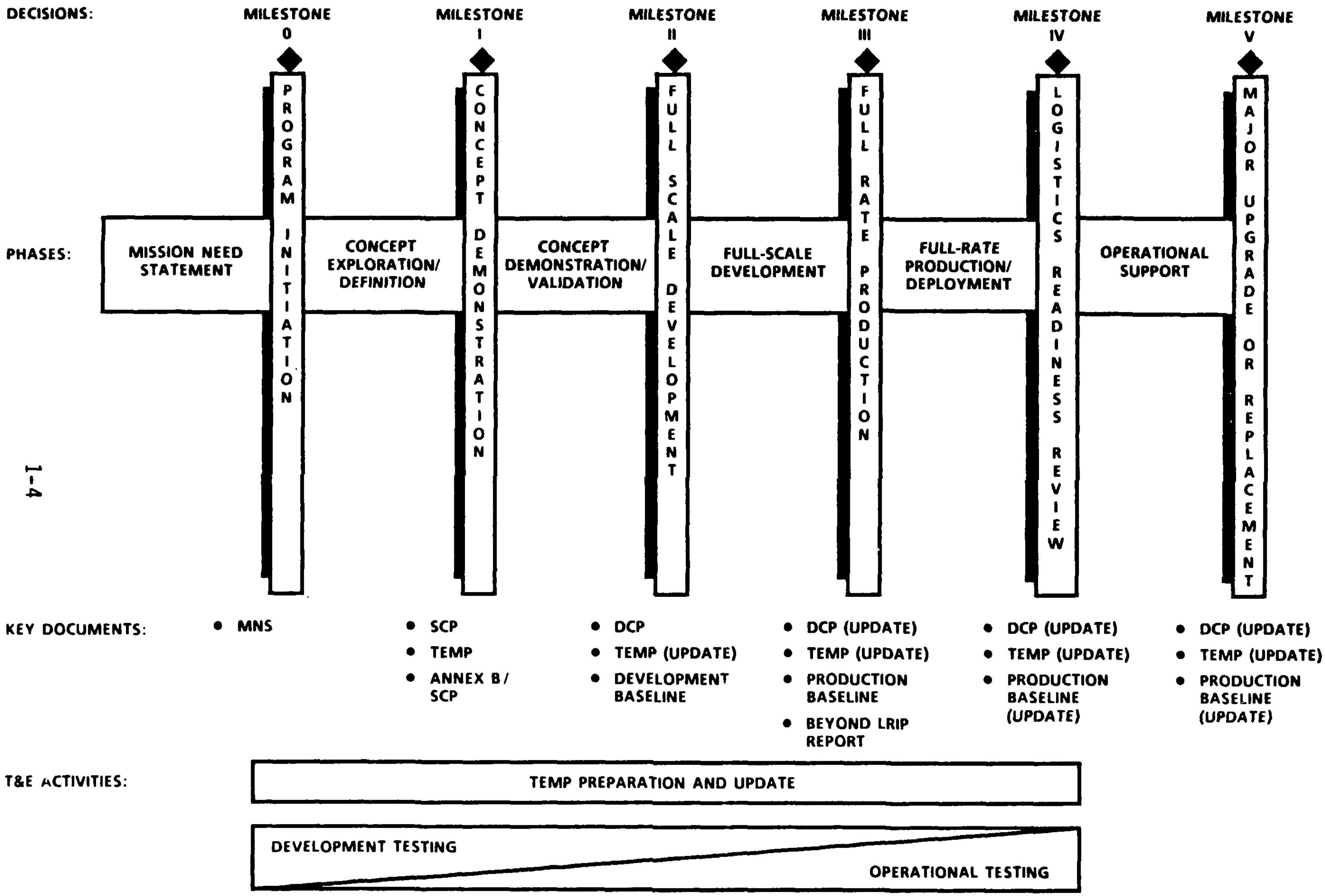


Figure 1-2. The Defense System Life Cycle

*7-2-MCL2-000185-01

brassboard or early prototype, are refined through study and analysis. This phase ends with the Milestone II decision to either enter into full-scale development or terminate the program. The Milestone II decision establishes more specific cost, schedule, and operational effectiveness and suitability goals and thresholds. Documents of particular interest to the T&E manager at the time of the Milestone II review include the Decision Coordinating Paper (DCP) and the updated TEMP. Additional documents prepared or updated at this time include: the COEA report, the Common Use Alternatives Statement, Independent Cost Estimates, the Manpower Estimate Report, the Acquisition Strategy Report, the Development Baseline, and the Operational Assessment for LRIP Funding or Long Lead Production Items.

1.2.3 Full-Scale Development Phase

During the Full-Scale Development Phase, the selected system and its principal items of support are fabricated. This phase ends with the Milestone III decision to produce the system. Key documents for the T&E manager at the time of the Milestone III review are an updated DCP, an updated TEMP, and the Beyond-Low-Rate Initial Production Report. The Beyond LRIP Report is required by law of the Director of Operational T&E to document his assessment of the adequacy of operational test and evaluation and the reported operational effectiveness and suitability of the system. Also mandated by law is the requirement to conduct Live Fire testing to proceed beyond LRIP. Other reports prepared in conjunction with Milestone III include Independent Cost Estimates, the Manpower Estimate Report, the Acquisition Strategy Report, and the Production Baseline. The results of completed OT&E are carefully considered at the time of the Milestone III decision.

1.2.4 Full-Rate Production and Operational Support Phases

The Milestone III decision is followed by a Full-Rate Production/Deployment Phase. This phase ends with a Logistics Readiness and Support Review (Milestone IV) to identify the actions and resources needed to achieve and maintain operational readiness and support objectives for the first several years of the fifth and final phase, the Operational Support Phase. The Milestone V decision at the end of the Operational Support Phase encompasses a review of a system's operational effectiveness, suitability, and readiness to determine whether major upgrades are necessary or deficiencies warrant consideration of replacement. In preparation for Milestones IV and V, the DCP, the TEMP, and the Production Baseline are updated to describe the program status, changes, and issues.

1.3 T&E and the Systems Engineering Process

In the early 1970s, Department of Defense (DoD) test policy became more formalized and placed greater emphasis on test and evaluation (T&E) as a continuing function throughout the acquisition cycle. These policies stressed the use of T&E to reduce acquisition risk and provide early and continuing estimates of the system's operational effectiveness and operational suitability. To meet these objectives, appropriate test activities had to be fully integrated into the overall development process. From a systems engineering perspective, test planning, testing, and analysis of test results are integral parts of the basic product definition process.

MIL-STD-499 defined systems engineering in the DoD context:

> System Engineering is the application of scientific and engineering efforts to (a) transform an operational need into a description of system performance parameters and a system configuration through the use of an iterative process of definition, synthesis, analysis, design, test, and evaluation; (b) integrate related technical parameters and assure compatability of all physical, functional, and program interfaces in a manner that optimizes the total system definition and design; (c) integrate reliability, maintainability, safety, survivability, human, and other such factors into the total engineering effort to meet cost, schedule, and technical performance objectives.

A system's life cycle begins with the user's needs, which are expressed as constraints, and the capability requirements needed to satisfy mission objectives. Systems engineering is essential in the earliest planning period, in conceiving the system concept, and defining performance requirements for system elements. As the detailed design is being done, systems engineers ensure balanced influence of all required design specialties (including "testability"), resolve interface problems, perform design reviews, perform trade-off analyses, and assist in verifying performance.

The days in which any one or two individuals can design a complex system, especially one of the huge weapon systems of the modern age, are past. The systems are too complex and require too much indepth knowledge over too broad a range of areas and technical disciplines for a small number of generalists to accommodate. System engineers coordinate the many specialized design engineers and are responsible for the integration of the pieces into a system.

Systems engineering through interdisciplinary integration manages the progress of product definition from system level, to configuration item level, detailed level, deficiency correction, and modifications/product improvements. Test results provide feedback for analysis of design progress toward performance goals. The tools of systems engineering include design reviews, configuration management, simulation, technical performance measurement, trade-off analysis, and specifications.

What products does systems engineering produce? It gives answers to what specialists are required, what segments to use, what nondevelopmental items to use, design performance limits and trade-off criteria, how to test, when to test, how to document (specifications), and what management controls to apply (technical performance measurement and design reviews).

Figure 1-3 depicts development testing (DT) and operational testing (OT) support of the technical reviews used to monitor the systems engineering process. More information on the reviews is contained in Chapter 8.

1.3.1 The Systems Engineering Process

The systems engineering process is the iterative logical sequence of analysis, design, test and decision activities that transforms an operational need into the descriptions required for production and fielding of all operational and support system elements. This process consists of four activities. They include functional analysis, synthesis, evaluation and decision (trade-off), and description of system elements.

The functional analysis activity identifies "what" the system, component, or part must do. It works from the top, downward assuring requirements traceability. It reveals alternative concepts. This is done without assuming "how" functions will be accomplished. The product is a series of alternative Functional Flow Block Diagrams (FFBD). A functional analysis can be applied at every level of development. At the system level, it may be a contractor or Service effort. Developmental testers assist the functional analysis activity during the concept exploration phase to help determine "what" each component's role will be as a part of the system being developed.

The synthesis activity involves invention; conceiving ways to do each FFBD task; to answer the "how" question. Next, the physical interfaces, which the how answers imply, are carefully identified (topological or temporal). All answers must reflect all technology selection factors. Synthesis tools include Requirements Allocation Sheets (RAS) which translate functional statements into design requirements, permitting a complex, long, interactive invention process with control, visibility, and requirements traceability. Developmental testers conduct Demonstration/Validation testing to determine how the components will perform their assigned functions to assist this synthesis activity.

SYSTEMS ENGINEERING MANAGEMENT

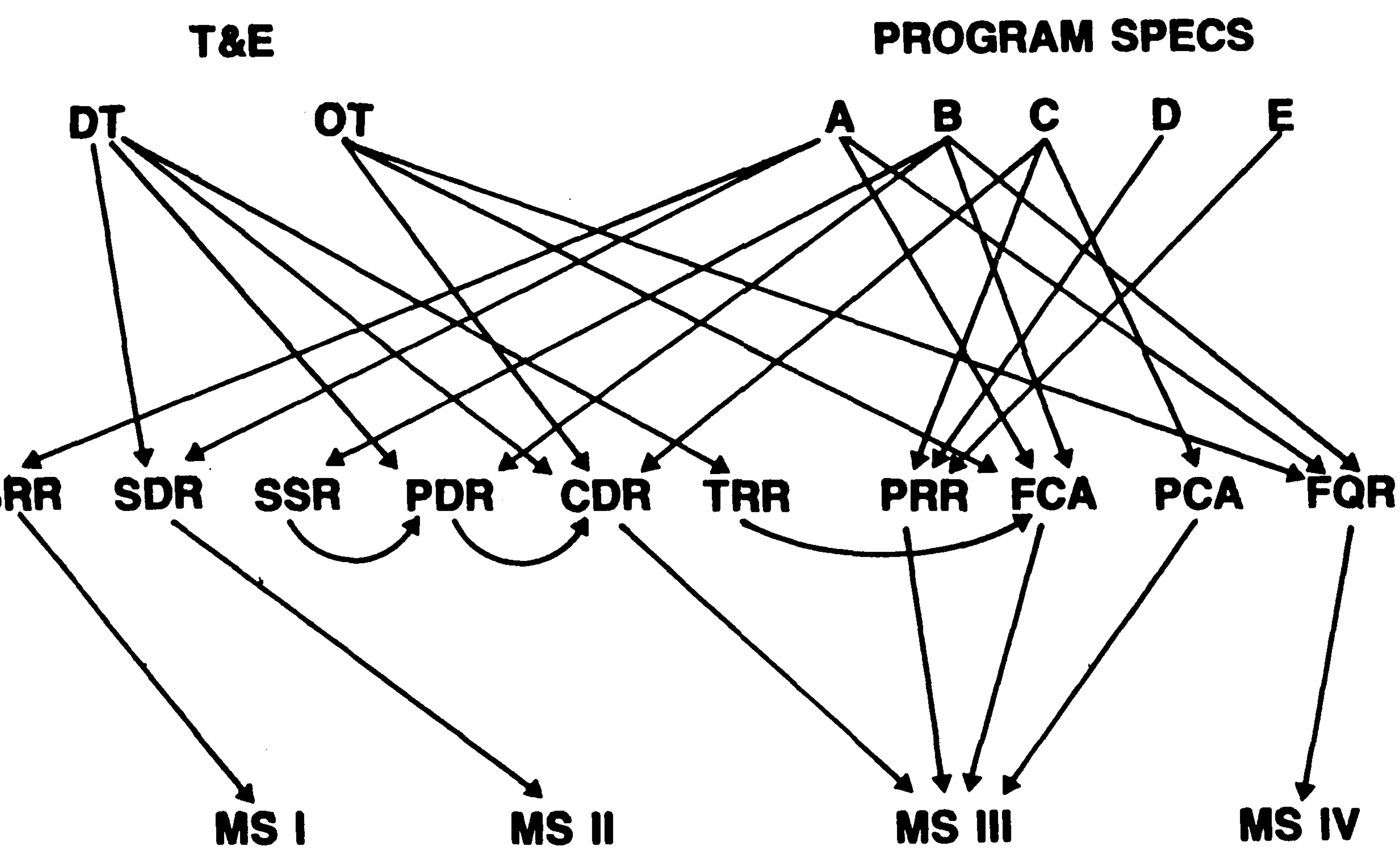


Figure 1-3. Systems Engineering Management

Source. Defense Systems Management College

The evaluation and decision activity is a trade-off of alternative approaches to "how". This activity is conducted in accordance with decision criteria set by higher level technical requirements for such things as life cycle costs, effectiveness, reliability, availability, maintainability, risk limits, schedule, etc. It is repeated at each level of development. The evaluation and decision activity is assisted by developmental testers during the later Demonstration/Validation phase and the Full-Scale Development phase when competitive testing between alternative approaches is performed.

The final activity is a description of system elements. This occurs as the results of the previous activities, as the final system's design is determined. This takes form as the specifications that are verified in testing and reviewed in the Physical Configuration Audit and the Functional Configuration Audit. Operational testers, during the Full-Scale Development phase, assist in this activity. They conduct operational testing of the test items/systems to help determine the personnel, equipment, facilities, software, and technical data requirements of the new system when used by typical military personnel. Figure 1-4, System Engineering Process, depicts the four activities that take place and their interaction.

1.3.2 The System Engineering Management Plan

The System Engineering Management Plan (SEMP) is a concise top level management plan for the integration of all system design activities. Its purpose is to make visible the organization, direction and control mechanisms, and personnel for the attainment of cost, performance, and schedule objectives. The SEMP defines and describes the type and degree of system engineering management, the system engineering process, and the integration of related engineering programs. The design evolution process described in the SEMP forms the basis for comprehensive test and evaluation planning.

The TEMP must be consistent with the SEMP. The testing program outlined in the TEMP must provide the technical performance measurements data required for all design decision points, audits, and reviews that are a part of the system's engineering process outlined in the SEMP. The configuration management process outlined in the SEMP controls the baselines for the test programs and incorporates design modifications to the baseline determined to be necessary by T&E.

The TEMP and the SEMP must be traceable to each other. The system description in the TEMP must be traceable to systems engineering documentation such as the Functional Flow Block Diagrams (FFBDs), the Requirements Allocation Sheets (RASs), and the Test Requirements Sheets (TRSs). Key functions and interfaces of the system with other systems must be described and correlated with the systems engineering documentation and the system specification (Type A). Operational and technical thresholds in the SEMP include specific performance requirements which become test

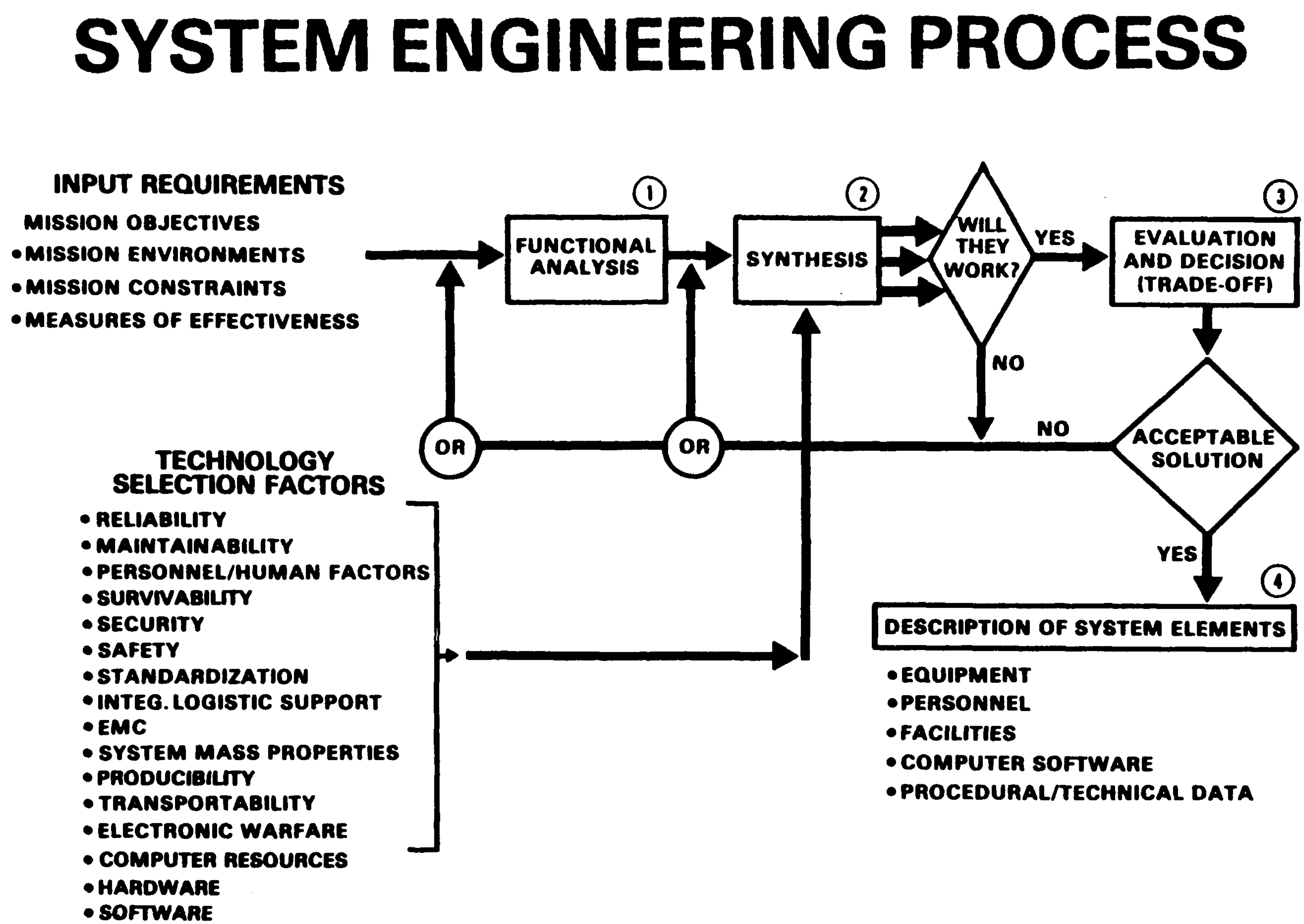


Figure 1-4. The System Engineering Process
Source. Defense Systems Management College

planning limits. They must be traceable through the planned systems engineering documentation and can be coorelated to the content of the TPM program. Failure criteria for reliability thresholds during OT&E testing must be delineated and agreed upon by the Program Manager and the Operational Test Director and reflected in the SEMP and the TEMP.

1.3.3 Technical Performance Measurement

The concept of technical performance measurement (TPM) is one of identifying critical technical parameters which are at risk during design, then tracking evaluation and test data; making predictions about whether or not the parameter can achieve final technical success (within the allocated resources), and then using these data to assist in managing the technical program.

The technical performance measurement program is an integral part of the T&E program. TPM is defined as product design assessment and forms the backbone of the development testing program. It estimates, through engineering analyses and tests, the values of essential performance parameters on the current design in a program. It serves as a major input in the continuous overall evaluation of operational effectiveness and suitability. Design reviews are conducted to measure the progress of the systems engineering progress. For more information, see Chapter 8. Figure 1-5 depicts the technical reviews that usually take place during the systems engineering process and the related specification documents.

1.3.4 Product Baselining and T&E

The systems engineering process establishes a product baseline throughout the acquisition cycle. This baseline can be modified with the results of engineering and testing. The testing to prove the technical or development baseline rarely is the same as the baseline for the operational testing or the production baseline.

Related to the product baseline is the process of configuration management. Configuration management benefits the test and evaluation community in two ways. Through configuration management, the baseline product to be used for testing is determined. Also, changes that occur to the baseline as a result of testing and design reviews are incorporated into the test article prior to the new phase of testing (to prevent retest of a bad design).

1.4 DEFINITIONS

T&E is the deliberate and rational generation of data concerning the nature of the emerging system and the creation of information useful to the technical and managerial personnel controlling its development. In the broad sense, T&E may be defined as all physical testing, modeling,

DESIGN REVIEWS

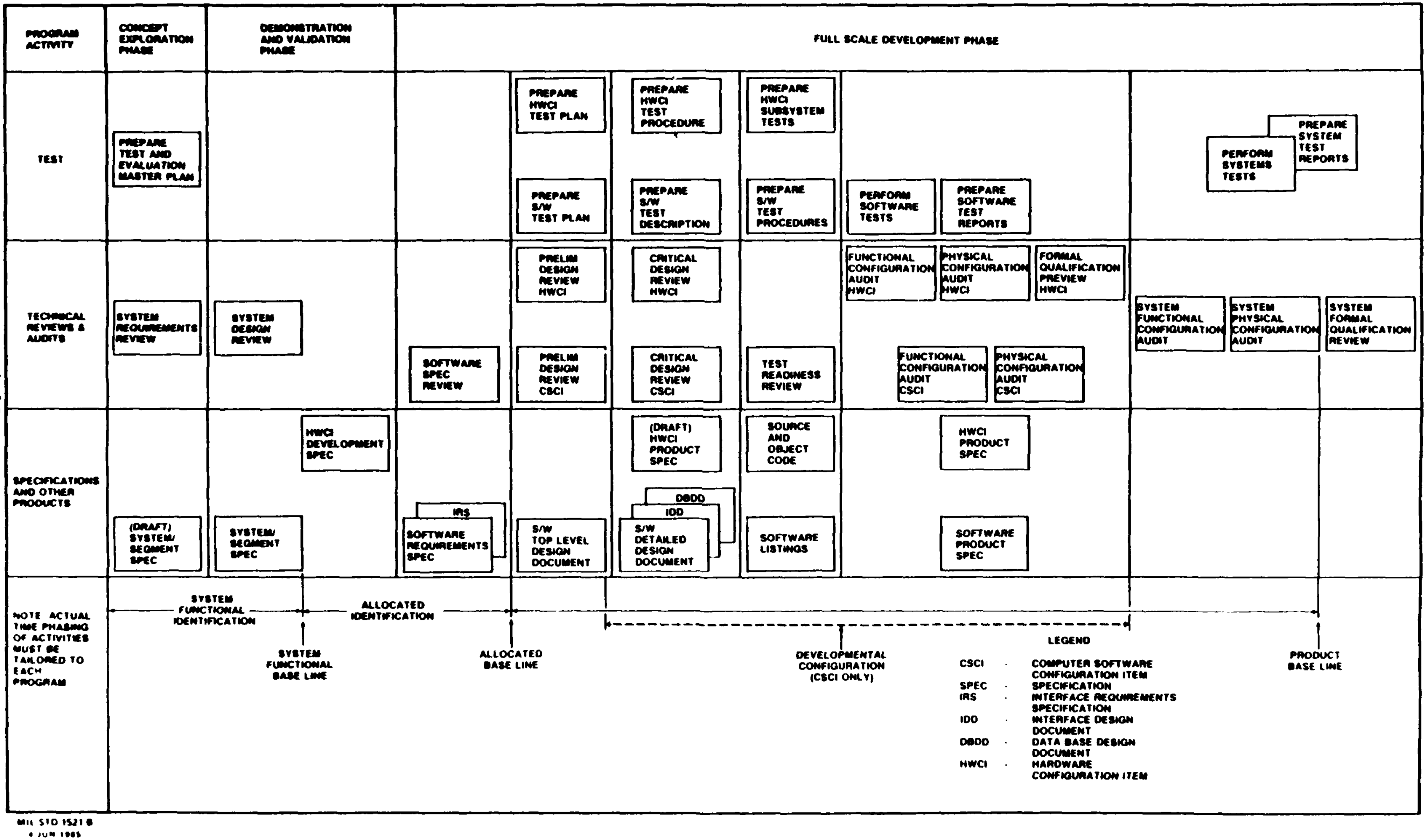


Figure 1-5. Design Review
Source. MIL STD 1521 B

simulation, and experimentation and related analyses performed during the course of the research, development, introduction and employment of a weapon system or subsystem. The Glossary: Defense Acquisition Acronyms and Terms, Defense Systems Management College, July 1987, defines "Test" and "Test and Evaluation" as follows:

A "test" is any program or procedure which is designed to obtain, verify, or provide data for the evaluation of: research and development (other than laboratory experiments); progress in accomplishing development objectives; or performance and operational capability of systems, subsystems, components, and equipment items.

"Test and Evaluation" is the process by which a system or components are compared against requirements and specifications through testing. The results are evaluated to assess progress of design, performance, supportability, etc.

1.5 SUMMARY

Test and evaluation is a technical management tool used to reduce risk throughout the defense system acquisition cycle. This cycle consists of five phases separated by discrete milestones. T&E results are used to support the design reviews that form an important part of the system engineering process used by system developers and to aid in the milestone decision process used by senior decision authorities in the Department of Defense.

CHAPTER 2
IMPORTANCE OF TEST AND EVALUATION

2.1 INTRODUCTION

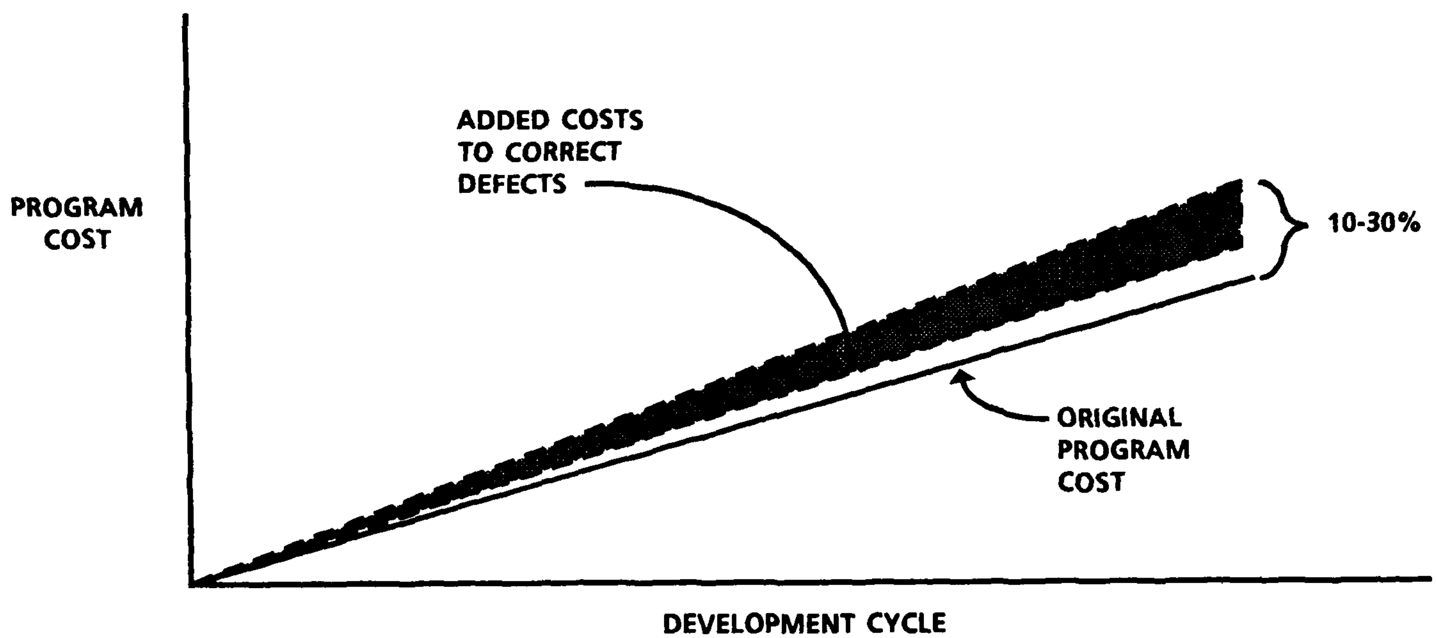
Risk analysis is the process of determining the probability that a specific combination of technical performance, schedule, and cost will or will not be attained if a planned course of action is followed. The responsibilities of a Program Manager and decision authorities center on assessing and controlling risk. This chapter describes how test and evaluation functions as a risk management tool. It also addresses the contribution T&E makes through the provision of empirical data before each milestone review. The support T&E provides to the design review process is addressed in Chapter 8.

2.2 TESTING AS A RISK MANAGEMENT TOOL

As shown in Figure 2-1, the cost of correcting defects in weapons has been estimated to add from 10 to 30 percent to the cost of each item (Reference 107). Such costly redesign and modification efforts can be reduced if carefully planned and executed test and evaluation programs are used to detect and fix system deficiencies sufficiently early in the acquisition process.

In 1983, the Assistant Secretary of Defense made the following statement regarding the importance of T&E to the Senate Committee on Governmental Affairs:

> . . . the criterion should not be how quickly we can field any new weapon, but rather how quickly we can field a new weapon that works. The only weapons that would be significantly delayed would be the ones that operational testing shows to be unsuitable for combat, and I cannot believe that any of us would advocate saddling our fighting forces with any of those. In fact, the most likely effect of operational testing is not to delay, but to accelerate the development process. Trying to fix a faulty weapon after it's in the field -- if it can still be fixed -- is a far slower process than fixing the design before it goes into production.



*7-1-MCL2-000584-14

Figure 2-1. Estimated Cost Increase to Correct Defects

Thus, test and evaluation may reduce cost, schedule and technical risks. There is a third type of risk involved in the development and acquisition of new systems -technical risk. Test and evaluation of parts, components, subsystems, and systems can also be used to estimate and manage this technical risk.

Test and evaluation results figure prominently in the decisions reached at design and milestone reviews. However, the fact that T&E results are required at major decision points does not presuppose that T&E results must always be favorable. The final decision responsibility lies with the executive who must examine the critical issues and weigh the facts at hand. Only he can determine the weight and importance that is to be attributed to a system's diverse capabilities and shortcomings -- only he can decide the degree of risk he is willing to accept. The decision authority will be unable to make this decision without a solid base of information provided by test and evaluation. Figure 2-2 illustrates the Life Cycle Cost of the System and how decisions impact the expenditures on the program.

A Defense Science Board 1983 Task Force focused on the reduction of risk in program acquisition (Reference 42). This group made the following observations:

- A poorly designed product cannot be properly tested or produced.

- The control techniques needed to successfully complete the design, test, and production of an item dictate the management system required.

- The industrial process of weapon system acquisition demands a better understanding and implementation of basic engineering and manufacturing disciplines.

- The industrial process is focused on the design, test, and production of a product.

- The design, test, and production processes are a continuum of interdependent disciplines. A failure to perform well in one area will result in failure to do well in all areas. When this happens -- as it does all too often -- a high-risk program results whose equipment is fielded later and at far greater cost than planned.

The Task Force developed a set of templates for use in establishing and maintaining low-risk programs. Each template describes an area of risk and then specifies technical methods for reducing that risk. Program Managers and test managers may wish to consult these templates for the

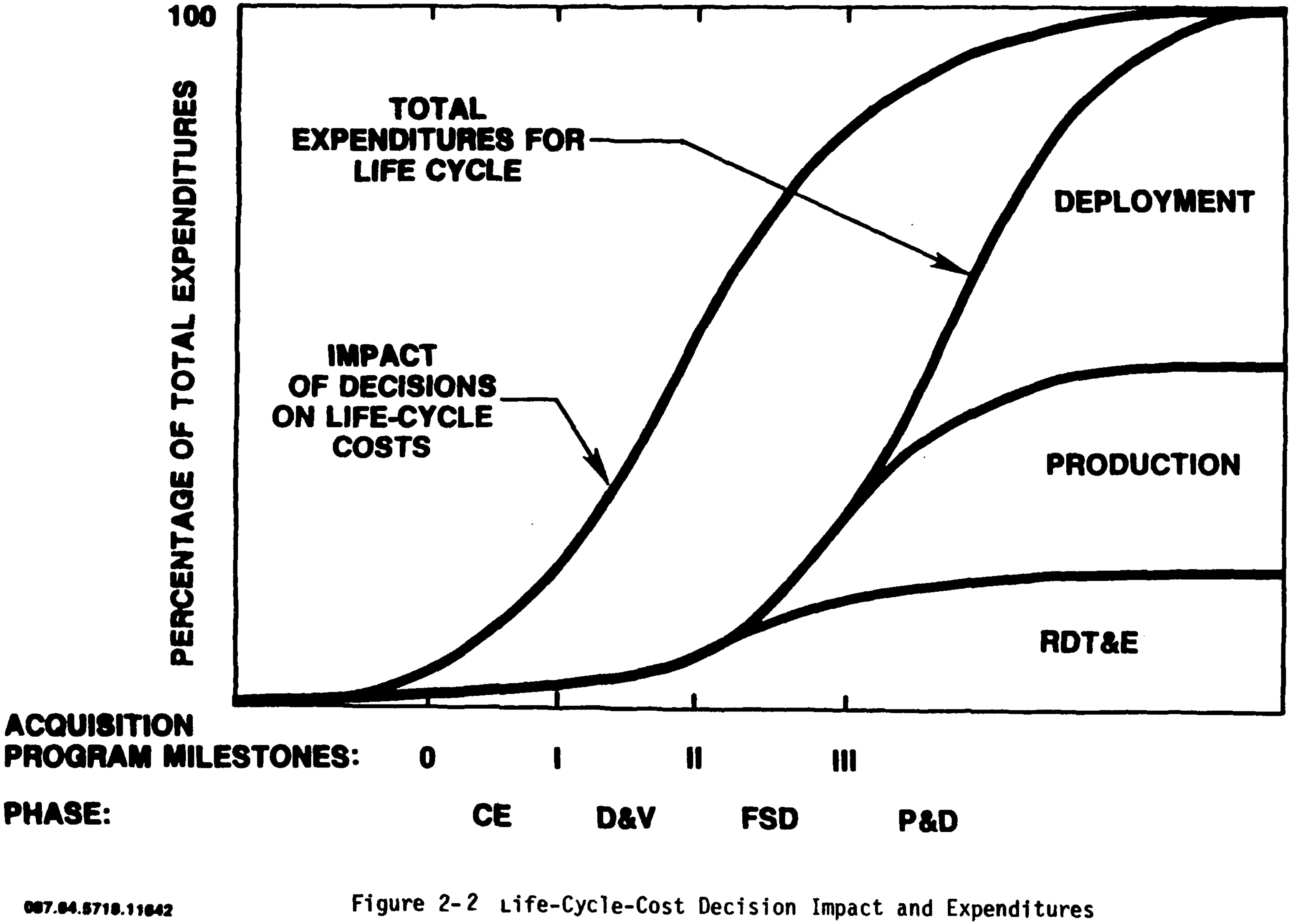


Figure 2-2 Life-Cycle-Cost Decision Impact and Expenditures
Source: Defense Systems Management College

guidance they provide in reducing the risks frequently associated with test programs (Reference 42, pages 4-10, 4-11). A sample risk management template is shown in Figure 2-3.

2.3 THE T&E CONTRIBUTION AT MAJOR MILESTONES

Test and evaluation progress is monitored by the Office of the Secretary of Defense (OSD) throughout the acquisition process. Their oversight extends to the major materiel acquisitions or designated acquisitions which is about 5% of all the acquisitions being managed within DoD. T&E officials within OSD render independent assessments to the Defense Acquisition Board, the Defense Acquisition Executive, and the Secretary of Defense at each major system milestone. These assessments are based on the following T&E information:

- The Test and Evaluation Master Plan (TEMP) and more detailed supporting documents developed by responsible Service activities.
- Service test agency reports and briefings; and,
- Development test and evaluation data from sources such as the Service program managers, laboratories, industry developers, and studies and analyses.

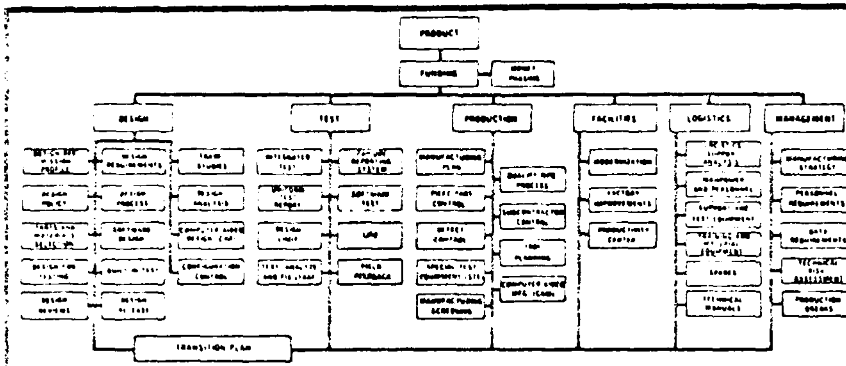
At Milestone I, the OSD T&E assessment reflects an evaluation of system concepts and alternatives based on specific goals and thresholds established in an approved TEMP. At Milestone II, it includes an assessment of previously established test plans and test results. At Milestone III, reviews verify the operational effectiveness and suitability of major weapon systems.

A primary contribution made by T&E is the detection and reporting of deficiencies that may adversely impact the performance capability or availability/supportability of a system. A deficiency reporting process is used throughout the acquisition process to report, evaluate, and track system deficiencies and to provide the impetus for corrective actions.

2.3.1 Test Contributions Prior to Milestone I

During the Concept Exploration/Definition Phase prior to Milestone I, laboratory testing, modeling and simulations are conducted by the contractor and the Development Agency to demonstrate and assess the capabilities of key subsystems and components. The test and simulation designs are based on the requirements documented in the Mission Need

TEMPLATE



AREA OF RISK

There is no way to test all possible paths during a development and acceptance test for a complex system involving immense logic complexity. Some of these paths eventually will be exercised after the system is deployed and some legitimate user interfaces will occur that were not tested specifically. These will result in software errors.

Many past studies on hardware illustrate how the cost of correcting a design error multiplies if the problem is not found until acceptance testing, production, or deployment. The same applies to software, but the cost for correcting software design errors after the design phase multiplies at a much greater rate.

Figure 4-3 is based on combined data from four major contractors and shows a multiple of 100:1 for cost to correct a design error after the system is operational.

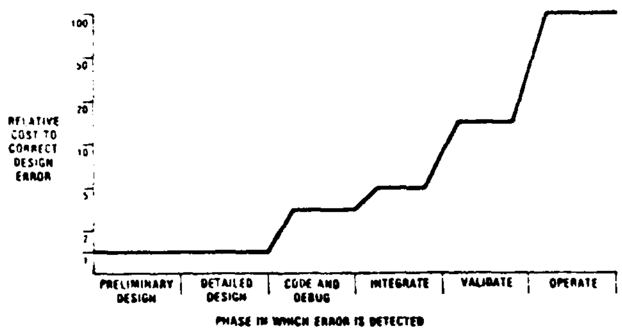
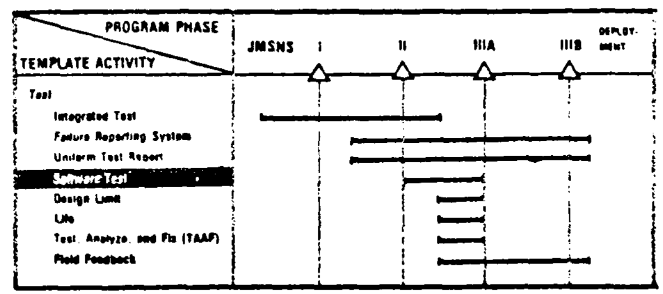


Figure 4-3 Relative Cost to Correct Design Error

OUTLINE FOR REDUCING RISK

- Up front money is available for testing software early in the design phase to prevent design and coding errors from being discovered after deployment.
- The software design allows the product to be testable. The test group is an active participant in software design reviews to ensure that the design is testable to the greatest degree.
- An independent test group is used to initiate the software test plan and to initiate testing at the functional module level early in the program.
- Test readiness reviews are used to ensure good software test planning.
- For extremely high reliability requirements, the verification and validation approach is used. An independent test group is used to verify by analysis or test every important test action.
- Useful definitions of error and failure are developed and software reliability growth is tracked during all test phases using a closed loop failure reporting system. Every failure is analyzed placing special emphasis on resolving anomalies.
- Stress testing and "worst case" testing are utilized to ensure that adequate design margins exist in memory loading, data rates, port timing, and other critical parameters.
- Security requirements are considered during software testing.

TIMELINE



The best approach in testing software is through testing at each of the early stages of design and coding to reduce the probability of errors escaping and surfacing during system integration tests and field use. Assurance of software/hardware interface compatibility is obtained by exhaustively testing the software in a total system test bed.

Figure 2-3. Sample Risk Management Template

SOURCE: "SOLVING THE RISK EQUATION IN TRANSITIONING FROM DEVELOPMENT TO PRODUCTION," DEFENSE SCIENCE BOARD TASK FORCE REPORT, 25 MAY 1983

Statement. Studies, analyses, simulation, and test data are used by the Development Agency to explore and evaluate alternative concept designs proposed to satisfy the requirements. Also during this period, the Operational Test and Evaluation Agency (OTA) monitors concept exploration T&E to gather information for future test and evaluation planning and to provide effectiveness and suitability inputs desired by the Program Manager. The OTA also conducts operational assessments, as feasible, to assess the operational impact of candidate technical approaches and to assist in selecting preferred alternative systems concepts.

Toward the end of the phase, the Development Agency prepares the DT&E System Concept Report to record and present T&E results of engineering and performance evaluations of system design(s) compared to stated requirements and concept specifications. The information in this report is incorporated into the Program Manager's Status Briefing and the System Concept Paper, key documents that form the basis for the Milestone I decision to proceed to the Concept Demonstration and Validation Phase.

2.3.2 Test Contributions Prior to Milestone II

During the Concept Demonstration/Validation Phase prior to Milestone II, concepts approved for demonstration and validation form the baseline which are used for detailed test planning.

The Development Agency conducts development test and evaluation during the Demonstration/Validation Phase to assist with engineering design, system development, and to verify attainment of technical performance specifications, and program objectives. DT&E includes T&E of components, subsystems, and prototype development models. T&E of functional compatibility and interoperability with existing and planned equipment and systems is also included. During this phase of testing, adequate DT&E is accomplished to ensure that engineering is reasonably complete (including survivability/vulnerability, compatibility, transportability, interoperability, reliability, maintainability, safety, human factors, and logistic supportability), that all significant design problems have been identified, and that solutions to these problems are in hand.

The Service Operational Test and Evaluation Agency conduct operational assessments to estimate the system's operational effectiveness and operational suitability, identify needed modifications, and provide information on tactics, doctrine, organization, and personnel requirements. The OT&E program is accomplished in an environment as operationally realistic as possible. Typical operational and support personnel are used to obtain a valid estimate of the user's capability to operate and maintain the system. The user of the system monitors test and evaluation during the Concept Demonstration and Validation Phase; among the most important products of user monitoring are the attainment of early orientation and advanced training, demonstrations of system performance, and valid operational test (OT) assessments of system maintainability and supportability.

The Development Agency prepares the results of demonstration and validation DT&E in report form for review by the Service Headquarters and the Service acquisition review council prior to system acquisition review by DoD. The report includes the results of testing with supporting information, conclusions, and recommendations for full-scale development. At the same time, the OT&E Agency prepares independent OT&E assessments which contain estimates of the system's operational effectiveness and suitability. OT&E assessments provide a permanent record of OT&E accomplished, an audit trail of OT&E data, test results, conclusions, and recommendations. This information is used to support the development of the Decision Coordinating Paper (DCP), which is prepared for Milestone II to recommend which of the alternative systems studied in the demonstration and validation phase will proceed into full-scale engineering development.

2.3.3 Test Contributions Prior to Milestone III

The objective of the Full-Scale Development (FSD) Phase prior to Milestone III is to design, fabricate and test a preproduction system that closely approximates the final product. Test and evaluation activities during this period yield much useful information. For example, data obtained during FSD test and evaluation is used to assist in evaluating the system's maintenance training requirements and in evaluating the proposed training program. Test results generated during FSD test and evaluation also support the user in refining and updating tactics.

During the FSD phase, development test and evaluation is conducted to satisfy the following objectives:

(1) To assess the critical technical issues, as specified in program documents, for example:

- (a) To determine how well the development contract specifications have been met;
- (b) To identify system technical deficiencies and appropriate corrective actions;
- (c) To determine whether the system is compatible and interoperable with existing and planned equipment or systems;
- (d) To estimate the reliability, maintainability, and availability of the system after it is deployed;

(e) To determine whether the system is safe and ready for operational test and evaluation (OT&E);
(f) To validate any configuration changes caused by correcting deficiencies, modifications, or product improvements;
(g) To assess human factors and identify limiting factors;

(2) To assess the technical risk and evaluate the tradeoffs among specifications, operational requirements, life cycle costs, and schedules;

(3) To assess the survivability, vulnerability, and logistic supportability of the system;

(4) To verify the accuracy and completeness of the technical documentation developed to maintain and operate the weapons system;

(5) To gather information for training programs and technical training materials needed to support the weapon system;

(6) To provide information on environmental issues to be used in preparing environmental impact assessments; and

(7) To determine system performance limitations and safe operating parameters.

Operational test and evaluation conducted prior to the production decision at Milestone III to achieve the following:

(1) To estimate the operational effectiveness and suitability of the system;

(2) To identify operational deficiencies;

(3) To recommend and evaluate changes in production configuration;

(4) To provide information for developing and refining logistics support requirements for the system and training, tactics, techniques, and doctrine;

(5) To provide information to refine operation and support (O&S) cost estimates, and to identify system characteristics or deficiencies that can significantly impact O&S costs;

(6) To determine whether the technical publications and support equipment are adequate; and

(7) To estimate the survivability of the system in the operational environment.

Thus, test and evaluation activities intensify during the Full-Scale Development Phase and make significant contributions to the overall acquisition decision process.

2.3.4 Test Contributions After The Production Decision

After Milestone III when the production decision is made, T&E activities continue to provide important insights. Tests described in the TEMP and not completed during the Full-Scale Engineering Development Phase are completed during the Production and Deployment Phase. The residual DT&E is usually limited to all-weather testing, correction of deficiencies, and engineering modifications. System elements are integrated into the final operational configuration, and development testing is completed when the system performance requirements are met. During the Production Phase, Government representatives normally monitor or conduct Production Acceptance Test and Evaluation (PAT&E). Each system is verified by PAT&E for compliance with the requirements and specifications of the contract.

Post production testing requirements may result from an acquisition strategy which calls for block changes to accommodate engineering changes or the use of pre-planned product improvements (P^3I) to allow parallel development of high risk technology and modular insertion of system upgrades into production equipment. Technology breakthroughs and significant threat changes may require system modifications. The development of the modifications will require development testing and if system performance is significantly changed, then operational testing may be appropriate.

Operational test and evaluation activities continue after the production decision in the form of Follow-on Operational Test and Evaluation. The initial phase of FOT&E may be conducted by either the OT&E Agency or the user commands, depending on Service directives. It is accomplished to verify the operational effectiveness and suitability of the production system and is to determine if deficiencies identified during initial Operational Test and Evaluation have been corrected. A second phase of FOT&E is conducted by the user to refine doctrine, tactics, techniques, and training programs for the life of the system.

The OT&E Agency prepares a final report at the conclusion of its management phase of FOT&E. This report records test results, describes the evaluation accomplished to satisfy critical issues and objectives established for FOT&E, and documents its assessment of deficiencies resolved during Full-Scale Development. Deficiencies that are not corrected are recorded with recommended corrective actions.

A final report on FOT&E is also prepared by the using command test team with emphasis on the operational utility of the system when operated, maintained, and supported by operational personnel using the concepts specified for the system. Specific attention is devoted to the following:

(1) The degree to which the system accomplishes the mission when employed by operational personnel in a realistic scenario with the appropriate organization, doctrine, threat (including countermeasures and nuclear threats), environment, and using tactics and techniques developed during earlier FOT&E;

(2) The degree to which the system can be placed in operational field use, with specific evaluations of availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, and training requirements;

(3) The conditions under which the system was tested including the natural weather and climatic conditions, terrain effects, battlefield disturbances and enemy threat conditions;

(4) The ability of the system to perform its required functions for the duration of a specified mission profile;

(5) System weaknesses such as the vulnerability of the system to exploitation by countermeasures techniques and the practicality and probability of an adversary exploiting a system susceptibility in combat.

A specific evaluation of the manpower and logistics changes needed for the effective integration of the system into the user's inventory is also made. These assessments provide essential inputs for the later phases of the system acquisition cycle.

2.4 SUMMARY

"Risk management is the means by which the program areas of vulnerability and concern are identified and managed." (Reference 20). Test and evaluation is the discipline that helps to illuminate those areas of vulnerability. The importance of T&E in the acquisition process is summarized well in a December 1986 report produced by the General Accounting Office. While the following remarks focus on operational test and evaluation, they also serve to underscore the importance of the T&E process as a whole:

> OT&E is the primary means of assessing weapon system performance. OT&E results are important in making key decisions in the acquisition process, especially the decision to proceed from full-scale development to production. OT&E results provide an indication

of how well new systems will work and can be invaluable in identifying ineffective or unreliable systems before they are produced.

Starting production before adequate OT&E is completed has some risks. If adequate OT&E is not done and the weapon system does not perform satisfactorily in the field, significant changes may be required. Moreover, the changes will not be limited to a few developmental models, but may also be applied to items already produced and deployed. In extreme situations, DoD also risks (1) deploying systems which cannot adequately perform significant portions of their missions, thus degrading our deterrent/defensive capabilities and (2) endangering the safety of military personnel who operate and maintain the systems.

CHAPTER 3

TYPES OF TEST AND EVALUATION

3.1 INTRODUCTION

This chapter provides an overview of development test and evaluation and operational test and evaluation -- two principal types of T&E; it also discusses the role of qualification testing as a subelement of development testing. Other important types of T&E are also introduced. They include: multiservice testing; joint test and evaluation; live fire testing; nuclear, chemical, and biological testing; and nuclear hardening and survivability testing. As Figure 3-1 illustrates, development test and evaluation and operational test and evaluation are performed throughout the acquisition process and identified by nomenclature that reflects the phase of the acquisition cycle in which they occur.

3.2 DEVELOPMENT TEST AND EVALUATION

Development test and evaluation (DT&E) is defined in DoD Directive 5000.3 as "that T&E conducted throughout the acquisition process to assist in engineering design and development and to verify that technical performance specifications have been met". DT&E is planned and monitored by the developing agency and is normally conducted by the contractor. However, the development agency may perform technical compliance tests prior to OT&E. It includes the T&E of components, subsystems, preplanned product improvement (P^3I) changes, and hardware/software integration, as well as preproduction and production qualification testing. It encompasses the use of models, simulations, and test beds, as well as prototypes or full-scale engineering development models of the system. DT&E may involve a wide degree of test complexity , depending upon the type of system or test article under development, e.g., tests of electronic breadboards, components, subsystems, or brassboards, experimental prototypes.

DT&E supports the system design process through a test-analyze-fix-retest approach that involves both contractor and government personnel. Because contractor testing plays a pivotal role in the total test program, it is important that an integrated test plan be established early by the contractor to ensure that the scope of the contractor's test program satisfies Government test objectives, as well as contractor objectives.

The Program Manager remains responsible for the ultimate success of the overall program. He and the test specialists on his staff must foster an environment that provides the contractor with sufficient latitude to pursue innovative solutions to technical problems, and at the same time, provides the data needed to make rational trade-off decisions between cost, schedule, and performance as the program progresses.

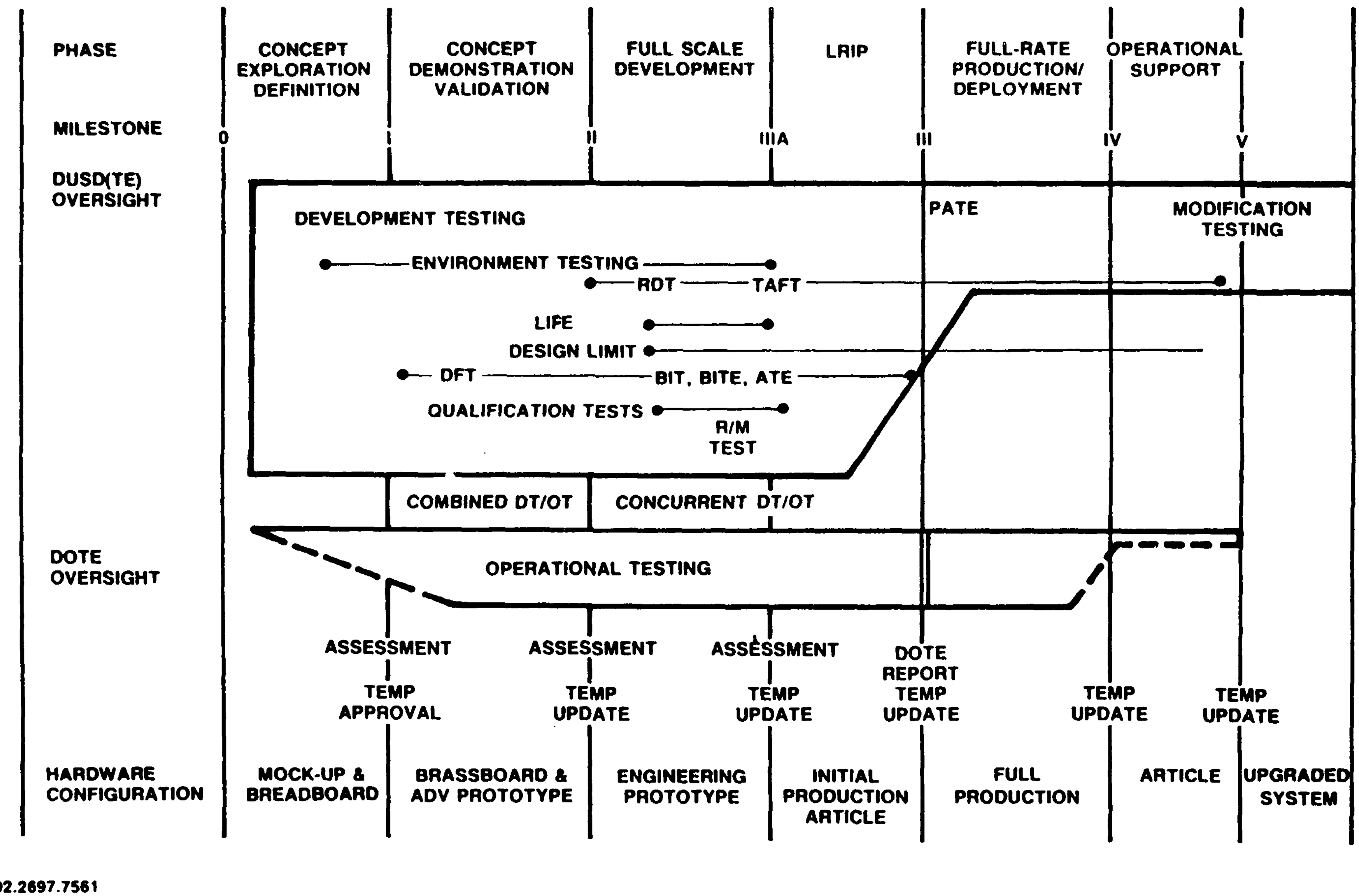


Figure 3-1, T&E Phases and the Acquisition Process

3.2.1 Preproduction Qualification Tests

Qualification testing is a form of development testing that verifies the design and manufacturing process. Preproduction qualification tests are formal contractual tests which confirm the integrity of the system design over the specified operational and environmental range. These tests usually use prototype or preproduction hardware fabricated to the proposed production design specifications and drawings. Such tests include contractual reliability and maintainability demonstration tests required prior to production release. Preproduction Qualification Test and Evaluation must be completed before Milestone III.

3.2.2 Production Qualification Tests

Production qualification tests are conducted on production items to ensure the effectiveness of the manufacturing process, equipment, and procedures. These tests are conducted on each item or a sample lot taken at random from the first production lot, and are repeated if the process or design is changed significantly, or a second or alternate source is brought on line. These tests are also conducted against contractual design and performance requirements.

3.3 OPERATIONAL TEST AND EVALUATION

3.3.1 The Difference Between Development and Operational Testing

Air Force Manual 55-43, published in June 1979, once contained the following account of the first operational test and evaluation; this anecdote serves as an excellent illustration of the difference between development and operational testing:

> The test and evaluation of aircraft and air weapon systems started with the contract awarded to the Wright brothers in 1908. This contract specified a craft which would lift two men with a total weight of 350 pounds, carry enough fuel for a flight of 125 miles, and fly 40 miles per hour in still air. The contract also required that testing be conducted to assure this capability.
>
> What we now call development test and evaluation (DT&E) was satisfied when the Wright brothers (the developer) demonstrated that their airplane could meet those first contract specifications. However, no immediate military mission had been conceived for the Wright Flyer. It was shipped to Fort Sam Houston, Texas, where Captain Benjamin

> D. Foulois, the pilot, had orders to "teach himself to fly." He had to determine the airplane's performance, how to maintain it, and the kind of organization that would use it. Cavalry wagon masters had to be trained as airplane mechanics, and Captain Foulois was his own instructor pilot.
>
> In the process, Captain Foulois subjected the Wright Flyer to test and evaluation under operational conditions. Foulois soon discovered operational deficiencies. For example, there was no seat on the airplane. During hard landings, Foulois' 130 pound frame usually parted company from the airplane. To correct the problem, Foulois bolted an iron tractor seat to the airplane. The seat helped, but Foulois still toppled from his perch on occasion. As a further improvement, Foulois looped his Sam Browne belt through the seat and strapped himself in. Ever since then, contoured seats and safety belts -- a product of this earliest "operational" test and evaluation -have been part of the military airplane.
>
> Captain Foulois' experience may seem humorous now, but it dramatically illustrates the need for operational testing. It also shows that operational testing has been going on for a long time.

As shown in Table 3-1 where development testing is focused on meeting detailed technical specifications, the operational test focuses on the actual functioning of the equipment in realistic combat environment in which the equipment must interact with men and peripheral equipment. Where DT&E and OT&E are separate activities and are conducted by different test communities, the communities must interact frequently and are generally complementary. DT&E provides a view of the potential to reach technical objectives, and OT&E provides an assessment of the system's potential to satisfy the user requirements.

3.3.2 The Purpose of Operational Test and Evaluation

Operational Test and Evaluation (OT&E) is conducted "for the purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users..." (DoD Directive 5000.3).

The definitions of operational effectiveness and operational suitability are outlined in DoDI 5000.2 are as listed below:

Operational Effectiveness. The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, tactics, survivability, vulnerability, and threat (including countermeasures, nuclear, and chemical and/or biological threats).

Operational Suitability. The degree to which a system can be placed satisfactorily in field use with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, and training requirements.

In each of the Services, operational testing is conducted under the auspices of an organization that is independent of the developer, in as operationally realistic environments as possible, with hostile forces representative of the anticipated threat and with typical users operating and maintaining the system. In other words, "OT&E is conducted to ensure that new systems meet the user's requirements, operate satisfactorily, and are supportable under actual field conditions" (Reference 2). The major questions addressed in OT&E are shown in Figure 3-2.

Table 3-1. Difference Between DT & OT

DT	OT
• Controlled by Program Manager Agency	• Controlled by Independent Agency
• One-on-One Tests	• Many-on-Many Tests
• Sterile Controlled Environment	• Tactical Environment with Operational Scenario
• Contractor Involvement	• No Contractor Involvement
• Trained Experienced Operators	• User Troops Recently Trained on Equipment
• Specific Performance Measurements and Goals	• Operational Effectiveness and Suitability Performance Measurements

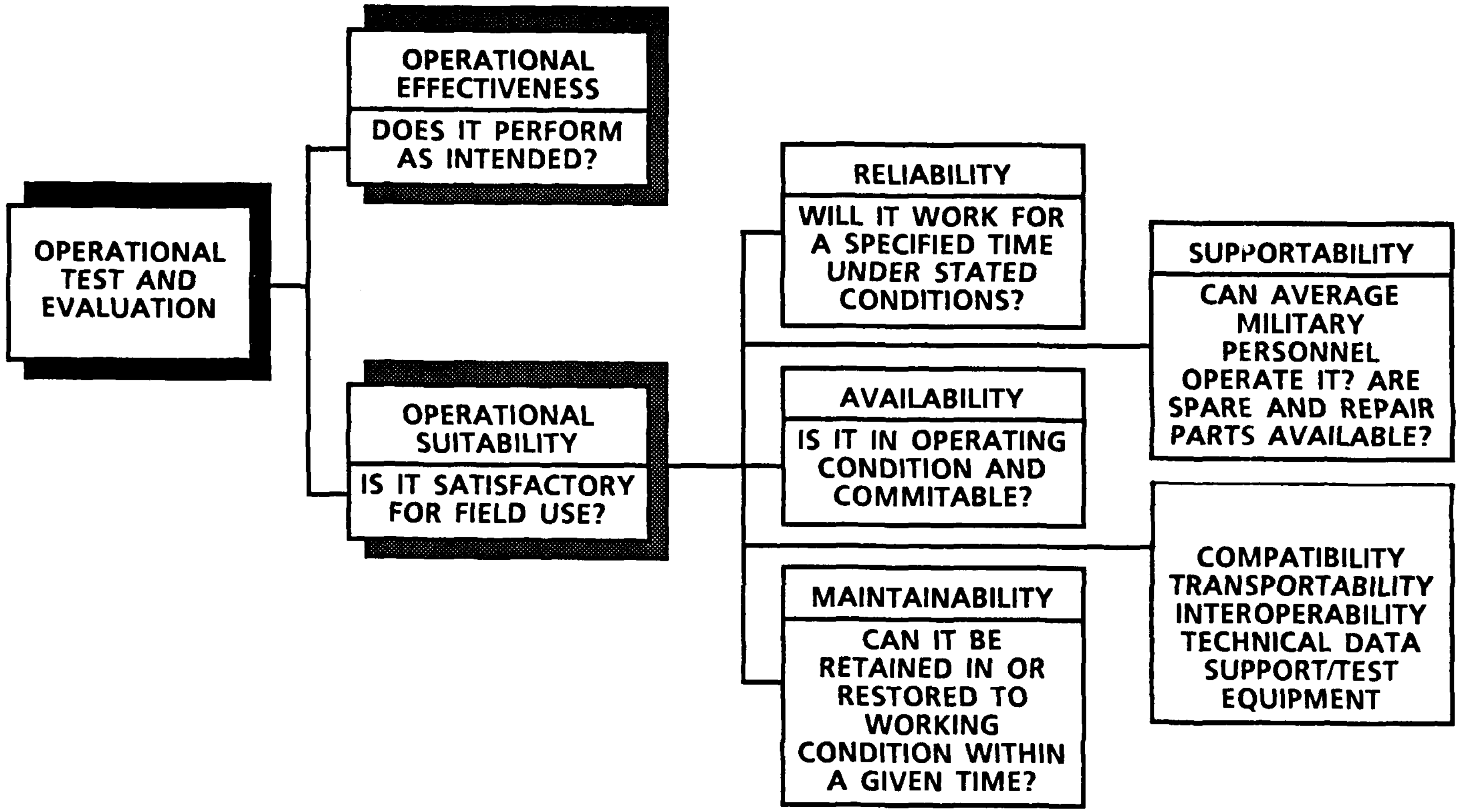


Figure 3-2. Major Questions Addressed in Operational Test and Evaluation

*7-1-MCL2-000584-05

3.3.3 Pre-Production Operational Test and Evaluation

OT&E performed before the full-rate production decision is frequently known as Initial Operational Test and Evaluation (IOT&E). The operational assessment normally takes place during the concept exploration/definition and demonstration/validation phases and is used to provide an early assessment of potential operational effectiveness and suitability and to project the system's potential to meet the user's requirements. The initial operational test begins during the full-scale development phase and ends with the full-rate production decision. This test may not be the first OT conducted on the system. The OT is conducted on a production representative system using typical operational personnel in as realistic a scenario as possible to verify a system's operational effectiveness and suitability, and to ensure that the system meets operational thresholds.

3.3.4 Follow-on Operational Test and Evaluation

OT&E performed after the start of Full Rate Production may be known as Follow-on Operational Test and Evaluation and is conducted during production and deployment. It too is sometimes divided into two separate activities. Preliminary FOT&E is normally conducted after the Initial Operational Capability is attained in order to assess full system capability. It is conducted by the OT&E organization to verify the correction of deficiencies, if required, and to assess system training and logistics status. Subsequent FOT&E is conducted on production items throughout the life of a system. The results are used to refine estimates of operational effectiveness and suitability; to update training, tactics, techniques, and doctrine; to identify operational deficiencies, and to identify the need for modifications. This FOT&E is conducted by the operating command.

3.4 MULTISERVICE TEST AND EVALUATION

Multiservice test and evaluation is that T&E conducted on a system being acquired for use by more than one Service. All affected Services and their respective operational test agencies participate in the planning, conduct, reporting, and evaluation of a multiservice test program. One Service is designated the lead Service and is responsible for the management of the program. The lead Service is charged (by DoD Directive 5000.3) with the preparation and coordination of a single report that reflects the system's operational effectiveness and suitability for each Service.

The management challenge in a multiservice test program stems from the fact that the items undergoing test will not necessarily be used by each of the Services for identical purposes. Differences between the Services in performance criteria, tactics, doctrine, configuration of armament or electronics, and the operating environment usually exist. As a result, a deficiency or discrepancy considered disqualifying by one Service is not necessarily disqualifying for all of the Services. It is incumbent upon the lead Service to establish a discrepancy reporting system that permits each participating Service to document all discrepancies noted. At the conclusion of a multiservice T&E, each participating OT&E agency prepares an independent evaluation report in its own format and submits that report through its normal Service channels. The lead Service OT&E agency prepares the documentation that goes forward to the Defense Acquisition Board; this documentation is coordinated with all participating OT&E agencies.

3.5 JOINT TEST AND EVALUATION

Joint Test and Evaluation is not the same as multiservice test and evaluation. Joint test and evaluation is a specific program activity sponsored and funded by the Office of the Secretary of Defense. Joint T&E programs are not acquisition oriented, instead are a means of examining joint Service tactics and doctrine. Past joint test programs have been conducted to provide information required by the Congress, by the Office of the Secretary of Defense, by the commanders of the Unified and Specified Commands, and by the Services. Joint tests are usually characterized as either Joint Deyelopment T&E or Joint Operational T&E. Joint development tests and evaluations focus on obtaining information in the following areas:

- System Requirements
- System Performance
- System Interoperability
- Technical Concepts
- Technical Improvements
- Improved Testing Methodologies
- Test Resource Requirements

Joint operational tests and evaluations are conducted using actual fielded equipment, simulators, or surrogate equipment in an exercise or operational environment to obtain data pertinent to operational doctrine, tactics, and procedures.

The Office of the Secretary of Defense reviews candidate nominations for joint test programs each year, and if a proposal is deemed appropriate for a joint test, a lead Service is selected and tasked to plan and execute the program using a test force of participating Service personnel.

The commanders of the four Service operational test agencies --the Army Operational Test and Evaluation Agency (OTEA), the Navy

Operational Test and Evaluation Force (OPTEVFOR), the Air Force Operational Test and Evaluation Center (AFOTEC), and the Marine Corps Operational Test and Evaluation Activity (MCOTEA) -- have agreed to a Memorandum of Agreement on Multi-Service OT&E and Joint T&E (Reference 37) that stipulates how both types of programs are to be managed.

3.6 LIVE FIRE TESTING

The Live Fire Test program was mandated by the Congress in the National Defense Authorization Act for Fiscal 1987 (Public Law 99-661) passed in November 1986. Specifically, this law stipulates that a major defense acquisition program may not proceed beyond low-rate initial production until realistic survivability or (in the case of missiles and munitions) lethality testing has been completed. Recently, an amendment has been proposed to substitute the word "vulnerability" for "survivability" to make the legislation more consistent with DOD practice.

In 1984, prior to the passage of this legislation, the OSD had chartered a joint test program designed to address similar questions relative to systems already in field use. This program, the Joint Live Fire Test, was initially divided into two distinct parts: Armor/Antiarmor and Aircraft. The program has the following objectives:

- Gather empirical data on the vulnerability of existing U.S. systems to Soviet weapons;
- Gather empirical data on the lethality of existing U.S. weapons against Soviet systems;
- Provide insights into the design changes necessary to reduce vulnerabilities and improve lethalities of existing U.S. weapon systems; and
- Calibrate current vulnerability and lethality models.

The recently-legislated Live Fire Test (LFT) Program complements the older Joint Live Fire (JLF) Program. While the <u>Joint</u> Live Fire (JLF) Program was designed to test systems already <u>fielded</u> which were not completely tested when they were developed, the spirit and intent of the <u>Live</u> Fire Testing (LFT) Legislation is to avoid the need to play "<u>catch-up</u>." This program requires the Services to test their weapons systems against the expected combat threat as early as possible to identify design characteristics which cause undue combat damage, or measure munitions lethality. Remedies for deficiencies can entail required retrofits, production stoppages or other more time-consuming solutions. The essential feature of Live Fire Testing is that appropriate threat munitions are fired against a major U.S. system configured for combat to test its vulnerability, and/or that a major U.S. munition or missile is fired against a threat target configured for combat to test the lethality of the munition or missile.

Live Fire Test and Evaluation Guidelines were issued by the Director, Live Fire Testing in May 1987 to supplement DoD Test and Evaluation Master Plan guidelines (DOD 5000.3-M-1) in areas pertaining to live fire testing (Reference 34). These guidelines encompass all major defense acquisition programs and define LFT requirements.

3.7 NUCLEAR, BIOLOGICAL, AND CHEMICAL WEAPONS TESTING

The testing of nuclear, biological and chemical (NBC) weapons is highly specialized and regulated. Program managers involved in these areas are advised to consult authorities within their chain of command for the specific directives, instructions, and regulations that apply to their individual situations. Nuclear weapons tests are divided into categories in which the responsibilities of the Department of Energy (DOE), the Defense Nuclear Agency (DNA), and the military Services are clearly assigned, with DOE responsible for nuclear warhead technical tests, DNA responsible for nuclear weapons effects tests, and the Services responsible for the testing of Service-developed components of nuclear subsystems. All nuclear tests are conducted within the provisions of the Limited Test Ban Treaty that generally restricts nuclear detonations to the underground environment. Nuclear weapons testing requires extensive coordination between Service and DOE test personnel (Reference 55).

Since the United States signed and ratified the Geneva Protocol of 1925, U.S. policy has been that the United States will never be the first to use lethal chemical weapons; it may, however, retaliate with chemical weapons if so attacked. With the signing and ratification of the 1972 Biological and Toxin Weapon Convention, the United States formally adopted the position that it would not employ biological or toxin weapons under any circumstances. All such weapons were destroyed in the early 1970s (Reference 38).

With regard to the retaliatory capability in chemical weapons, the Service secretaries are responsible for ensuring that their organizations establish requirements and determine the military characteristics of chemical deterrent items and chemical defense items. The Army has been designated the DoD Executive Agent for DoD chemical warfare, research, development and acquisition programs (Reference 39).

Unite States policy on chemical warfare seeks to:

- Deter the use of chemical warfare weapons by other nations;
- Provide the capability to retaliate if deterrence fails; and
- Achieve the early termination of chemical warfare at the lowest possible intensity. (Reference 39).

In addition to the customary development tests (conducted to determine if a weapon meets technical specifications) and operational tests (conducted to determine if a weapon will be useful in combat), chemical weapons testing involves two types of chemical tests: chemical mixing and biotoxicity. Chemical mixing tests are conducted to obtain information on the binary chemical reaction. Biotoxicity tests are performed to assess the potency of the agent generated. Chemical weapons testing, of necessity, relies heavily on the use of nontoxic simulants since such substances are more economical and less hazardous, and since open air testing of live agents was restricted in 1969 (Reference 39).

3.8 NUCLEAR HARDNESS AND SURVIVABILITY TESTING

Nuclear hardness is a quantitative description of the physical attributes of a system or component that will allow it to survive in a given nuclear environment. Nuclear survivability is the capability of a system to survive in a nuclear environment and to accomplish its mission. DoD policy requires the incorporation of nuclear hardness and survivability features in the design, acquisition, and operation of major and nonmajor systems that must perform critical missions in nuclear conflicts. Nuclear hardness levels must be quantified and validated. (Reference 12).

The test and evaluation techniques used to assess nuclear hardness and survivability include: nuclear testing, physical testing in a simulated environment, modeling, simulation, and analysis. Although nuclear tests provide a high degree of fidelity and valid results for survivability evaluation, they are not practical for most systems due to cost, long lead times, and international treaty constraints. Underground testing is available only on a prioritized basis for critical equipment and components and is subject to a frequently changing test schedule. Physical testing provides an opportunity to observe personnel and equipment in a simulated nuclear environment. Modeling, simulation and analysis are particularly useful in the early stages of development to provide early projections before system hardware is available. These methods are also used to furnish assessments in area that, because of safety or testing limitations, cannot be directly observed through nuclear or physical testing.

3.9 SUMMARY

Test and evaluation is a technique used to address critical questions during system development. These questions may involve: technical issues (development testing), effectiveness, suitability, and supportability issues (operational testing), issues affecting more than one Service (multiservice and joint testing), vulnerability and lethality issues (live fire testing), nuclear survivability, or the use of other than conventional (i.e., nuclear, biological, or chemical) weapons.

CHAPTER 4
EVALUATION

4.1 INTRODUCTION

This chapter describes the "evaluation" portion of the test and evaluation process. It stresses the importance of establishing and maintaining a clear audit trail from system requirements through critical issues, evaluation criteria, test objectives, and measures of effectiveness, to the evaluation report. The importance of the use of data from all sources is discussed as are the differences in approaches to evaluating technical and operational data.

4.2 DIFFERENCE BETWEEN "TEST" AND "EVALUATION"

The following distinction has been made between the functions of "test" and evaluation":

> While the terms "test" and "evaluation" are most often found together, they actually denote clearly distinguishable functions in the RDT&E process. "Test" denotes the actual testing of hardware/software -models, prototypes, production equipment, computer programs -- to obtain data, including software, valuable in developing new capabilities, managing the process, or making decisions on the allocation of resources.
>
> "Evaluation" denotes the process whereby data are logically assembled and analyzed to aid in making systematic decisions. (Reference 10)

To summarize, evaluation is "the review and analysis of qualitative or quantitative data obtained from design review, hardware inspection, testing or operational usage of equipment" (Reference 2).

4.3 THE EVALUATION PROCESS

The evaluation process requires careful focus on the development of an overall test and evaluation plan that will provide timely answers to critical issues and questions required by decision authorities as part of the milestone review process.

A functional block diagram of a generic (i.e., not Service-specific) evaluation process is shown in Figure 4-1. The process begins with the identification of a deficiency or need and the documentation

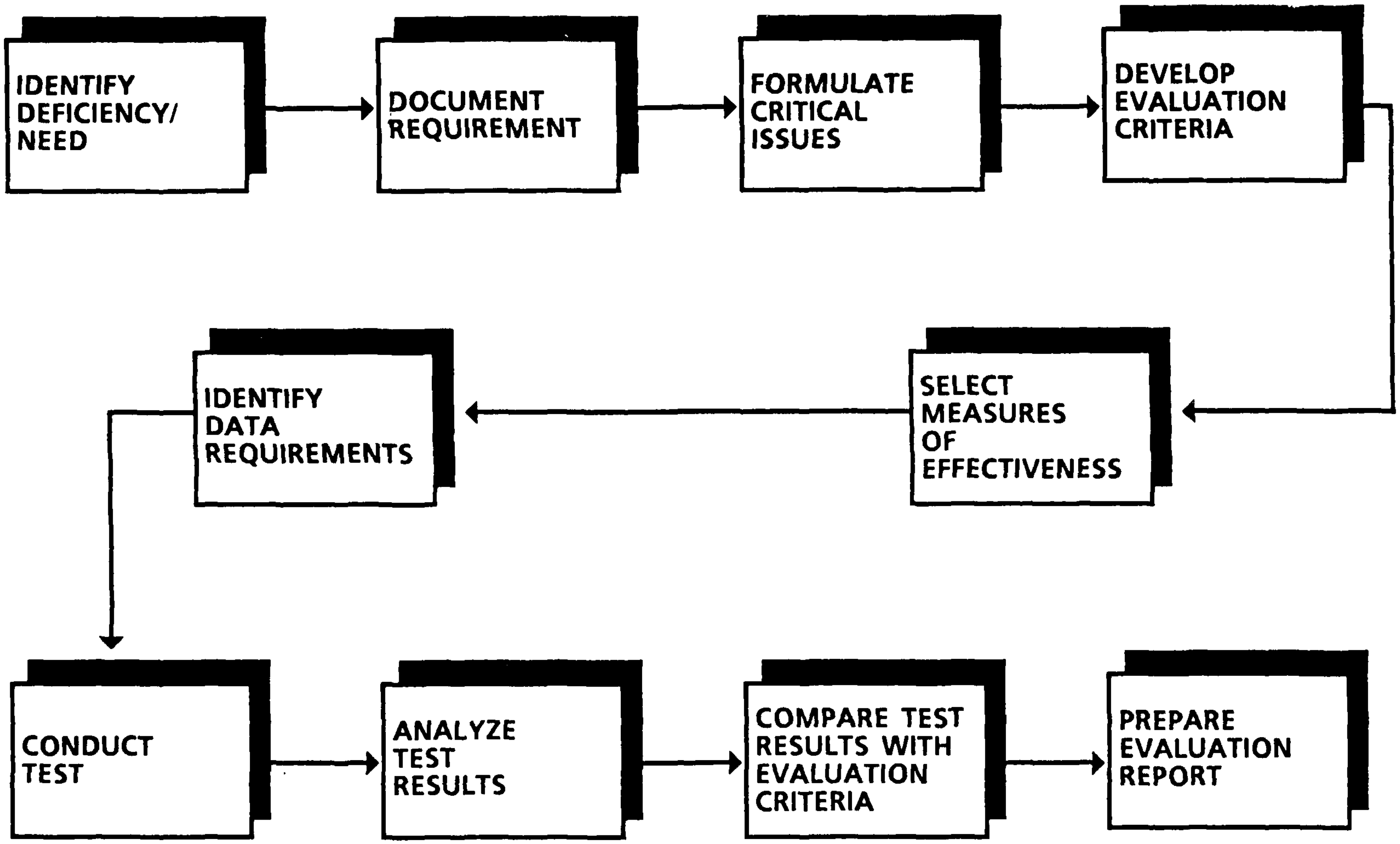


Figure 4-1. Functional Block Diagram of the Evaluation Process

*7-1-MCL2-000584-07

of an operational requirement. It continues with the identification of critical issues that must be addressed to determine if the system meets the requirement. Criteria must then be established to define required performance or supportability thresholds and to evaluate progress in reaching them. Test and evaluation specialists then decompose the issues into measurable test elements, conduct the necessary testing, review and analyze the test data, weigh the test results against the evaluation criteria, and prepare an evaluation report for the decision authorities.

4.4 ISSUES AND CRITERIA

Issues are questions regarding a system that require answers during the acquisition process. Those answers may be needed to aid in the development of an acquisition strategy, to refine requirements and designs, or to support milestone decision reviews. Criteria are the standards by which the issues may be addressed (Reference 62).

4.4.1 Hierarchy of Issues

As Figure 4-2 illustrates, issues can be categorized in a hierarchical system according to the subject matter they address.

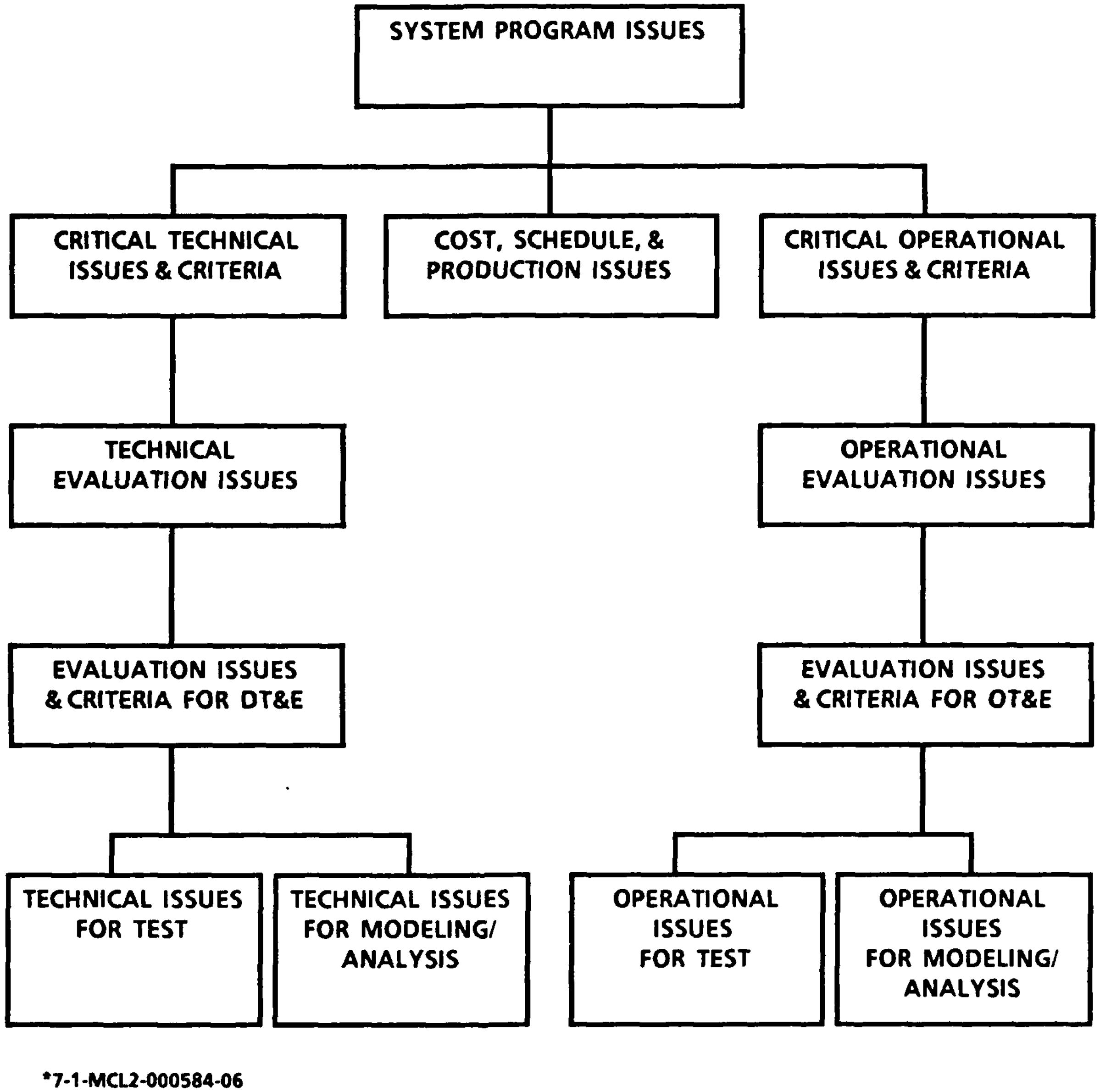
4.4.1.1 System Program Issues/Critical Issues

System program issues are often known as "critical issues." Critical issues are defined in DOD Manual 5000.3-M-1 as "those questions relating to a system's operational, technical, support or other capability, that must be answered before the system's overall worth can be estimated/evaluated and that are of primary importance to the decision authority in allowing the system to advance to the next acquisition phase" (Reference 6). System program issues are normally identified in the System Concept Paper (SCP), Decision Coordinating Paper (DCP), and requirements document. The system development and production baseline documentation will provide much of the performance data required to develop the issues.

4.4.1.2 Evaluation Issues

Evaluation issues are those issues that must be addressed by technical or operational evaluators during the acquisition process. Evaluation issues are separated into technical and operational issues and included in the Test and Evaluation Master Plan (TEMP).

Technical issues primarily concern technical characteristics or engineering specifications and are normally addressed in development testing. Operational issues concern physical characteristics (weight, shape, volume, sturdiness) and operational characteristics (functions to be performed by equipment/concepts). They address the system's operational effectiveness and suitability when examined in a realistic



SOURCE: ADAPTED FROM ARMY REGULATION 70-10, "RESEARCH, DEVELOPMENT, AND ACQUISITION TEST AND EVALUATION," 30 APRIL 1986.

Figure 4-2. Hierarchy of Issues

operational environment. Evaluation issues are addressed by whatever means necessary (analysis/survey, modeling, simulation, demonstration or testing) to resolve the issue. Issues that require test data are further referred to as test issues.

4.4.1.3 Test Issues

Test issues are a subset of evaluation issues and address areas of uncertainty that require test data to resolve the issue adequately. Test issues are separated into technical issues that are addressed by the DT&E community and operational issues that are addressed by the OT&E community. Test issues are divided into critical and non-critical categories. DoD Directive 5000.3 requires that all critical test and evaluation issues, objectives, methodologies, and evaluation criteria be defined during the initial establishment of an acquisition program. Critical test issues are documented in the TEMP. The directive further requires that these evaluation criteria serve to define the testing required for each phase of the acquisition process and serve as the structure to guide the testing program (Reference 62).

4.4.2 Criteria

Criteria are statements of a system's required technical performance and operational effectiveness, suitability, and supportability. Criteria are often expressed in terms of "goals and thresholds". (Some Services, however, specify performance and supportability requirements exclusively in terms of thresholds and avoid the use of the concept of goals.) These performance measurements provide the basis for collecting data used to evaluate/answer test issues.

Criteria must be unambiguous and assessable whether stated qualitatively or quantitatively. They may compare the mission performance of the new system to the one being replaced, compare the new system to a predetermined standard, or make a comparison of the mission performance results from using the new system to not having the system. Criteria are the final values deemed necessary by the user. As such, they should be developed in close coordination with the system user, other testers, and specialists in all other areas of operational effectiveness and suitability. These values may be changed as systems develop and associated testing and evaluation proceeds. For instance, a Milestone II performance threshold may be less demanding than the threshold required for Milestone III (Reference 61).

4.4.2.1 Goals and Thresholds

A <u>threshold</u> is the minimum acceptable level of performance required by a test article or system to perform its mission. Thresholds are stated quantitatively whenever possible. Specification of minimum acceptable performance in measurable parameters is essential to the selection of appropriate measures of effectiveness which, in turn, heavily influence test design. Thresholds are of value only when actual performance can be measured against them. The function of T&E is to verify the attainment of required thresholds. OPNAVINST 5000.42C states:

> T&E is the major control mechanism of the acquisition process. Programs advance from one phase to the next, not by the calendar or planned schedule, but by actual achievement of present thresholds, verified by T&E (Reference 69).

Goals are levels of performance (established by the user) above that required which, if achieved, will provide additional operational capability. Goals are not normally addressed by the operational tester whose primary concern is the requirement. While goals may be of some value to the developer during demonstration and validation, their relevance decreases beyond Milestone II when most system performance decisions have been made and their utility in supporting a production decision is diminished. However, if, on occasion, it is advantageous to the user to establish goals after Milestone II, the associated evaluation criteria must be clearly identified as addressing goals and not requirements (Reference 83). The Navy does not use the concept of goals in its acquisition or test documentation.

4.4.2.2 Evaluation Criteria

Evaluation criteria are standards by which the achievement of required technical and operational effectiveness/suitability characteristics or the resolution of technical or operational issues may be judged (Reference 62). Evaluation criteria are associated with objectives, subobjectives, and measures of effectiveness (MOEs). For example, an MOE (e.g., airspeed) may have an associated evaluation criterion (e.g., 450 knots) against which the actual performance (e.g., 425 knots) is compared to arrive at a rating.

Requirements, thresholds, and goals established in early program documentation form the basis for evaluation criteria. If program documentation is incomplete, the tester may have to develop evaluation criteria in the absence of specific requirements. In this case, the operating, implementing, and supporting commands must agree to the criteria before the test organization makes use of them in assessing test results. Ensuring that values can be related to the user's operational requirements is a most important consideration when identifying and establishing evaluation criteria. Testers must also ensure that evaluation criteria are updated if requirements change (Reference 83).

4.5 EVALUATION PLANNING

4.5.1 Evaluation Planning Techniques

Evaluation planning is an iterative process that requires formal and informal analyses of system operation (e.g., threat environment, system design, tactics, and interoperability). Techniques that have proved effective in evaluation planning include: process analysis techniques, design or engineering analysis techniques, matrix analysis techniques, and dendritic analysis techniques (Reference 61).

4.5.1.1 Process Analysis Techniques

Process analysis techniques consist of thinking through how the system will be used in a variety of environments, threats, missions, and scenarios in order to understand the events, actions, situations, and results that are expected to occur. This technique aids in the identification and clarification of appropriate measures of effectiveness (MOEs), test conditions, and data requirements.

4.5.1.2 Design/Engineering Analysis Techniques

Design or engineering analysis techniques are used to examine all mechanical or functional operations that the system has been designed to perform. These techniques involve a systematic exploration of each hardware and software component, its purpose, its performance bounds, its manpower and personnel considerations, known problem areas, and impact on other components. Exploration of the way a system operates compared to the functions it is intended to perform, often identifies issues, MOEs, specific data, test events, and required instrumentation.

4.5.1.3 Matrix Analysis Techniques

Matrix analysis techniques are useful for analyzing any situation where two classifications need to be cross-referenced. For example, a matrix of "Types of Data" versus "Means of Data Collection" can reveal not only types of data having no planned means of collection, but also redundant or backup collection systems. Matrix techniques are useful as checklists, as organizational tools, or as a means of identifying and characterizing problem areas. Matrix techniques are effective for tracing system operational requirements through contractual specification documents through issues and criteria to sources of individual data or specific test events.

4.5.1.4 Dendritic Analysis Techniques

Dendritic analysis techniques are an effective means for decomposing critical issues to the point where actual data requirements and test measurements can be identified. In these techniques, issues are successively broken down into objectives, subobjectives, measures of effectiveness, and data requirements in a root-like structure such as that depicted in Figure 4-3. In this approach, objectives are used to clearly express the broad aspects of T&E related to the critical issues and the overall purpose of the test. Subobjectives are developed as subsets of the objectives and are designed to treat specific and addressable parts of the objectives. Each subobjective is traceable as a direct contributor to one objective and, through it, is identifiable as a direct contributor to addressing one or more critical issues (Reference 83). Each test objective and subobjective is also linked to one or more Measures of Effectiveness (quantitative or qualitative measures of system performance under specified conditions) which, in turn, are tied to specific data elements. The dendritic approach has become a standard military planning technique.

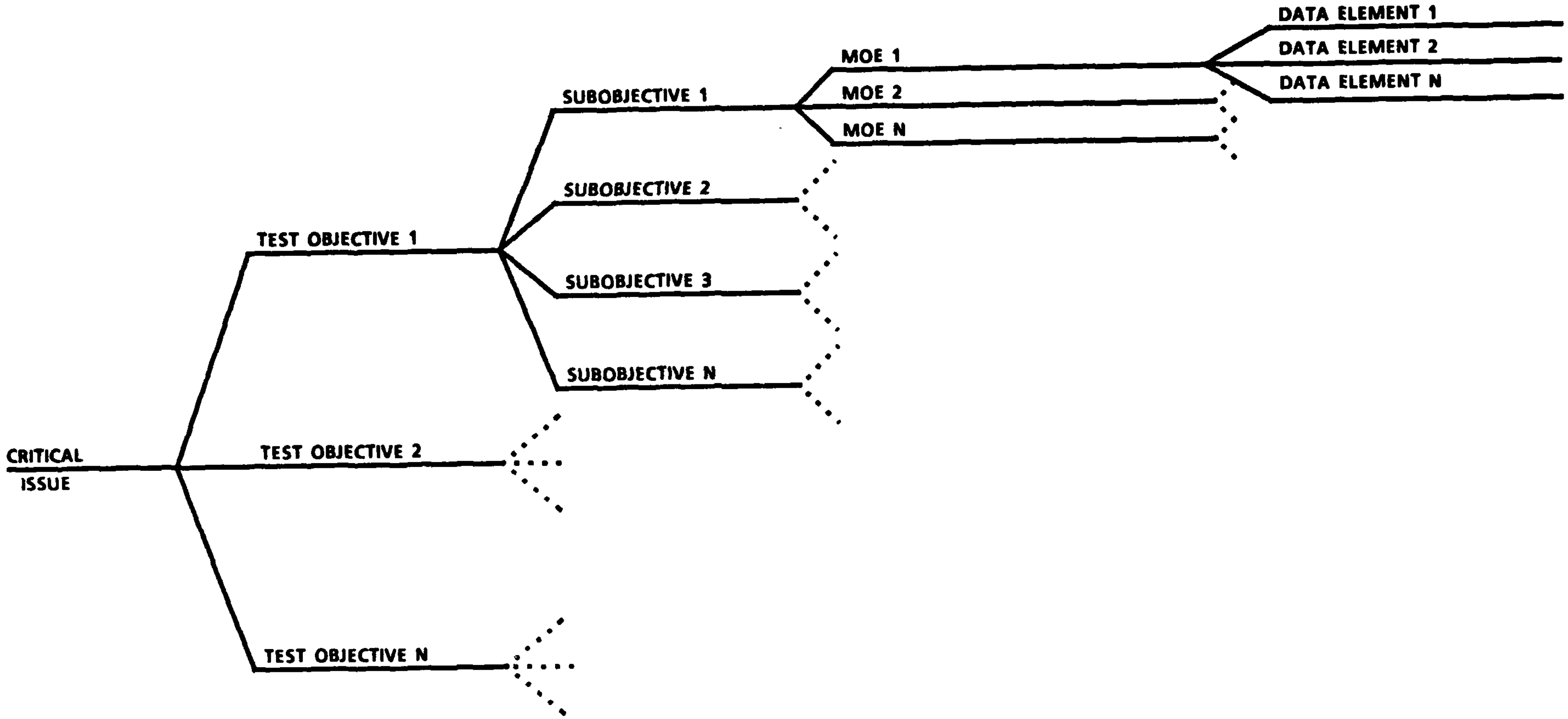
4.5.2 Sources of Data

As evaluation and analysis planning matures, focus turns toward identifying data sources as a means for obtaining each data element. Initial identification tends to be generic such as: engineering study, simulation, modeling, or contractor test. Later identification reflects specific studies, models, and/or tests. A data source matrix is a useful planning tool to show where data are expected to be obtained during the T&E of the system.

There are many sources of data that can contribute to the evaluation. Principal sources include: studies and analyses; models, simulations, and wargames, contractor testing, development testing, operational testing, and comparable systems.

4.6 EVALUATING DEVELOPMENT AND OPERATIONAL TESTS

Technical and operational evaluations employ different techniques and have different evaluation criteria. DT&E is often considered "technical" evaluation while OT&E addresses the operational aspects of a system. Technical evaluation deals primarily with instrumented tests and statistically valid data. An operational evaluation deals with operational realism and the uncertainties of combat (Reference 76). DT&E uses technical criteria for evaluating system performance. These criteria are usually parameters that can be measured during controlled DT&E tests that are particularly important to the developing organization and the contractor but of less interest to the independent operational tester. The operational tester focuses on issues such as demonstrating target acquisition at useful ranges or air superiority in combat or the probability of accomplishing a given mission. For example, during DT&E, firing may be conducted on a round-by-round basis with each shot designed to test an individual specification or parameter with other parameters



CAPABILITY OF CANDIDATE RADAR "X"	- DETERMINE DETECTION CAPABILITY - DETERMINE TRACKING CAPABILITY o o o	- DETERMINE MEAN/MEDIAN DETECTION RANGE - DETERMINE EASE OF OPERATION OF CONTROLS/DISPLAYS - DETERMINE FALSE TARGET RATES o o o	- MEAN AND VARIANCE OF DETECTION RANGE - % TIME OPERATORS JUDGED OPERATION OF CONTROLS & DISPLAYS SATISFACTORY - MEAN AND VARIANCE OF THE NUMBER OF FALSE TARGETS PER SCAN o o	- MEASURED/OBSERVED DETECTION RANGE - OPERATOR'S COMMENTS - OBSERVATION OF SCANS - OBSERVATION OF FALSE ALARMS o o o

Figure 4-3. Dendritic Approach to Test and Evaluation

*7-1-MCL2-000584-08

held constant. Such testing is designed to measure the technical performance of the system. In contrast, in OT&E proper technical performance as regards individual specification/parameters is de-emphasized and the environment is less controlled. The OT&E authority must assess whether, given this technical performance, the weapon system is operationally effective and operationally suitable when employed under realistic combat (with opposing force) and environmental conditions by typical personnel.

The emphasis in DT is strictly on the use of quantitative data to verify the attainment of the technical specifications. Quantitative data are usually analyzed using some form of statistics. Versus DT&E, qualitative data takes on increasing importance in OT&E when effectiveness and suitability issues are being explored. Many techniques are used to analyze qualitative data. They range from converting expressions of preference or opinion into numerical values to establishing a consensus by committee. For example, a committee may assign values to parameters such as "feel", "ease of use", "friendliness to the user", and "will the user want to use it" on a scale of 1 to 10. Care should be exercised in the interpretation of the results of qualitative evaluations since, when numbers are assigned to them, the meaning of such things as the average evaluation and its standard deviation can have meanings different from quantitative data averages and standard deviations.

4.6.1 Technical Evaluation

The Service's materiel development organizations are usually responsible for oversight of all aspects of DT&E, including the technical evaluation. The objectives of a technical evaluation are:

o To assist the developers by providing information relative to technical performance; qualification of components; compatibility, interoperability, vulnerability, lethality, transportability, and survivability; reliability, availability, and maintainability (RAM); manpower and personnel; system safety; integrated logistics support; correction of deficiencies; accuracy of environmental documentation; and refinement of requirements.

o To ensure the effectiveness of the manufacturing process of equipment and procedures through production qualification T&E.

o To confirm readiness for OT by ensuring that the system is stressed beyond the levels expected in the OT environment.

o To provide information to the decision authority at each decision point regarding a system's technical performance and readiness to proceed to the next phase of acquisition.

o To determine the system's operability in the required climatic and realistic battlefield environments to include natural, induced, and countermeasure environments (Reference 54).

4.6.2 Operational Evaluation

The independent operational test and evaluation authority is responsible for the operational evaluation. The objectives of an operational evaluation are:

o To assist the developers by providing information relative to operational performance; doctrine, tactics, training, logistics; safety; manpower, technical publications; RAM; correction of deficiencies; accuracy of environmental documentation; and refinement of requirements.

o To ensure that only systems that are operationally effective and suitable are delivered to the operating forces.

o To provide information to the decision authority at each decision point as to a system's operational effectiveness and suitability, and readiness to proceed to the next phase of acquisition.

o To assess, from the user's viewpoint, a system's desirability, considering systems already fielded, and the benefits or burdens associated with the system (Reference 84).

4.7 SUMMARY

A primary consideration in identifying the information to be generated by a test and evaluation program is a clear understanding of the decisions the information will support. The importance of structuring the T&E program to support the resolution of critical issues cannot be overemphasized. It is the responsibility of those involved in the test and evaluation process to ensure that the proper focus is maintained on key issues, that the T&E program yields information on critical technical and operational issues, that all data sources necessary for a thorough evaluation are tapped, and that evaluation results are communicated in an effective and timely manner. The evaluation process is evolutionary throughout the acquisition cycles.

CHAPTER 5

TEST-RELATED DOCUMENTATION

5.1 INTRODUCTION

During the course of a defense acquisition program, many documents are developed that have significance for those responsible for testing and evaluating the system. This chapter is designed to provide an overview of these documents.

As Figure 5-1 shows, test-related documentation spans a broad range of materials. It includes requirements documentation such as the Mission Need Statement (MNS), program decision documentation such as the System Concept Paper (SCP) and Decision Coordinating Paper (DCP), program management documentation, such as the Acquisition Strategy, Baseline documentation, the System Engineering Management Plan (SEMP), the Integrated Logistics Support Plan (ILSP), and the Test and Evaluation Master Plan (TEMP). Of importance to the Program Manager and to test and evaluation managers are additional test program documents such as specific test designs, test plans, outline test plans/test program outlines, evaluation plans, and test reports. This chapter concludes with a description of the End-of-Test Phase and Low-Rate Initial Production (LRIP) Reports, two special purpose T&E status reports that are used to support the milestone decision process.

5.2 REQUIREMENTS DOCUMENTATION

5.2.1 Continuing Mission Area Analyses

DoDD 5000.1 requires the Services to conduct continuing mission analyses of their assigned areas of responsibility. These Mission Area Analyses (MAA) may result in recommendations to initiate new acquisition programs to reduce or eliminate operational deficiencies. If a need cannot be met through changes in tactics, strategy, doctrine, or training and a materiel solution is required, the needed capability is described in a document known as an Operational and Organizational (O&O) Plan, Required Operational Capability (ROC), Army; an Operational Requirement (OR), Navy; or a Statement of Operational Need (SON), Air Force. When the cost of a proposed acquisition program is estimated to exceed $200 million for research, development, test and evaluation or $1 billion for procurement, it is considered a major program and requires a "Mission Need Statement." The MAA is completed at the beginning of a program and reviewed at the end (Milestone V) to evaluate system modifications or new starts.

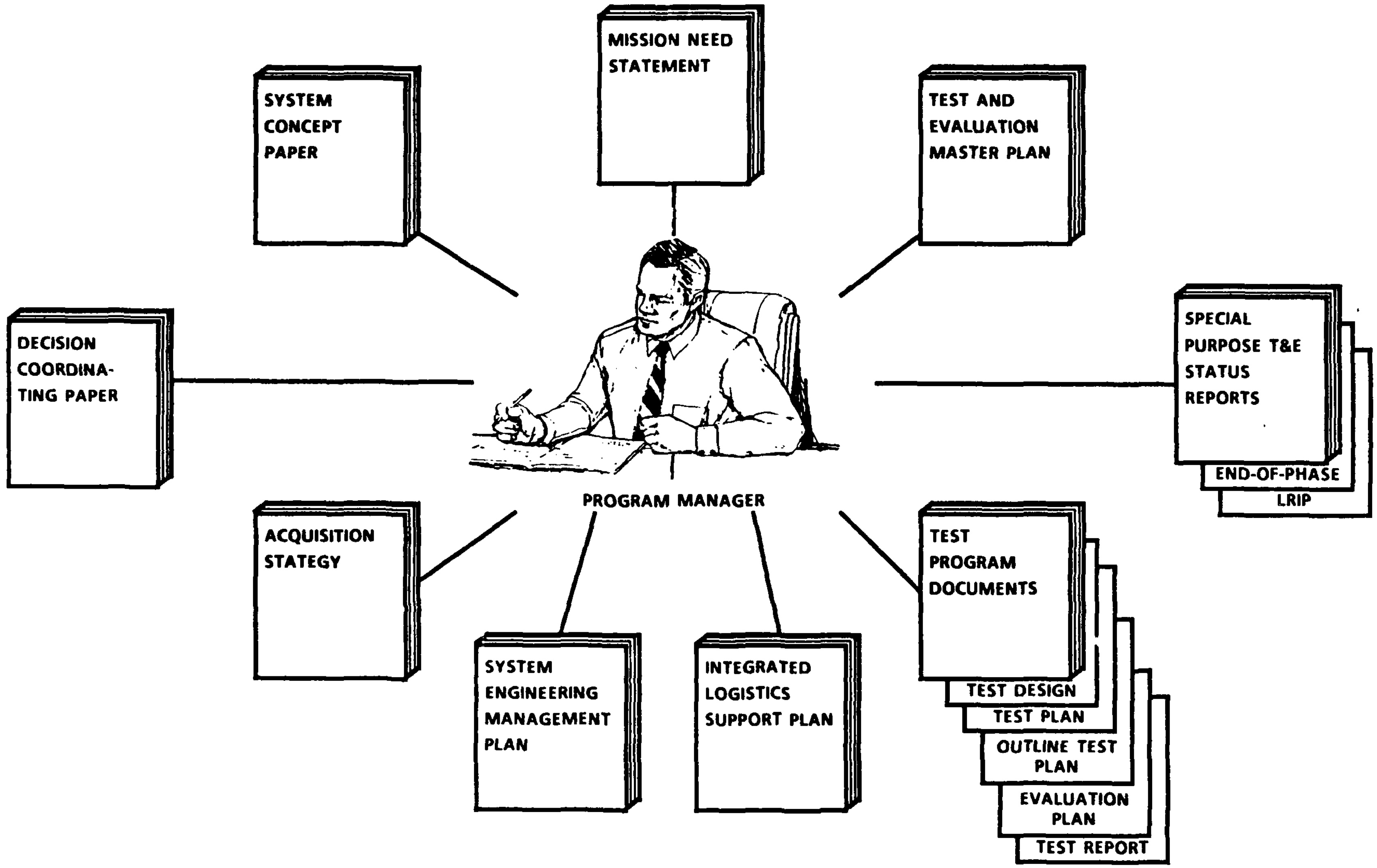


Figure 5-1. Test-Related Documentation

*7-1-MCL2-000584-09

5.2.2 Mission Need Statement

The Mission Need Statement is submitted to the Defense Acquisition Executive either prior to or concurrent with the annual Program Objectives Memorandum (POM) submission. The content and format of the Mission Need Statement is prescribed by DoD Instruction 5000.2. In summary, it contains the following:

- A description of the mission need
- The projected threat
- Timing and priority of the need
- Alternatives for meeting the need
- A recommendation concerning the feasibility of a cooperative development program with an allied nation
- An assessment of the technical risk involved
- Funding implications
- Constraints
- A proposed acquisition strategy

The Mission Need Statement or the other requirements documents are of particular value to the tester since they form the basis for the initial identification of critical issues that will be addressed in the test program.

5.3 PROGRAM DECISION DOCUMENTATION

5.3.1 *Acquisition Decision Memorandum*

Secretary of Defense decisions at major milestones in the acquisition process are recorded in a document known as an Acquisition Decision Memorandum (ADM). The ADM documents a SECDEF decision on a Mission Need Statement at Milestone 0, on a System Concept Paper (SCP) at Milestone I, or on a Decision Coordinating Paper (DCP) at Milestones II and III. In conjunction with an ADM, the SCP and DCP are also primary program guidance documents providing goals/thresholds for systems performance.

5.3.2 System Concept Paper

The System Concept Paper (SCP) documents the results of the concept exploration phase and is used to support the Milestone I decision. It identifies the concepts that will be developed further in the demonstration and validation phase and provides reasons for the elimination of previously considered alternative concepts. It describes the proposed acquisition strategy and establishes broad goals and thresholds for the system's cost, acquisition schedule, and operational effectiveness and suitability. The purpose and content of the SCP are set forth in DoD Instruction 5000.2. Test managers will find the information contained in the SCP useful in scoping the overall test program since the SCP identifies the key areas of technological and producibility risk that must be reduced by research and development and validated by test and evaluation before the Milestone II decision is made.

5.3.3 Decision Coordinating Paper

The Decision Coordinating Paper (DCP) is used as a milestone decision supporting document, updated for subsequent milestone decisions. It summarizes the results of the demonstration and validation phase and is used to support the Milestone II decision. The DCP identifies program alternatives and establishes explicit goals and thresholds for program cost, schedule, operational effectiveness, and operational suitability. The DCP is updated prior to Milestone III to describe program changes since Milestone II and to propose revisions in goals or thresholds, if required. The DCP prepared prior to Milestone III contains a discussion of the operational test and evaluation results that demonstrate that the system is ready to proceed to full-rate production. Instructions for the preparation of the DCP are contained in DoD Instruction 5000.2.

5.4 PROGRAM MANAGEMENT DOCUMENTATION

5.4.1 Acquisition Strategy

An acquisition strategy must be formulated at the outset of a development program. The strategy constitutes a broad set of concepts that provides direction and control for the overall development and production effort. The Acquisition Strategy is updated, as required, throughout the life of a program. The level of detail reflected in the Acquisition Strategy can be expected to increase as a program matures. The Acquisition Strategy serves as a conceptual basis for formulating functional plans such as the System Engineering Management Plan, Integrated Logistics Support Plan, and the Test and Evaluation Master Plan.

It is important that T&E interests be represented as the Acquisition Strategy is formulated because the Acquisition Strategy should:

- o Provide an overview of the T&E planned for the program, ensuring that adequate T&E is conducted prior to the production decision;
- o Discuss plans for providing adequate quantities of test hardware;
- o Describe how test hardware will be funded "up front;" and
- o Identify test and evaluation organizations that will have T&E responsibility for the program.

5.4.2 Baseline Documentation

The Baseline development starts with Mission Need Statement at Milestone 0. It is included in Annex B of the System Concept Paper at Milestone I and transitions to a Development (MSII) and Production (MSIII) Baseline. The Baseline Documentation (DODI 5000.2) is used to enhance stability and control cost growth of selected major programs. When the baseline is signed by the Program Manager, Service Acquisition Executive, and Defense Acquisition Executive, it becomes a mechanism to control program instabilities. Baseline documents are required for all programs in full-scale development. The document must describe the systems requirements, unit and development cost, and milestone schedule. Programs in production are required to have a baseline document consisting of system requirements, total program cost, and production schedules. System baseline documentation is a good source of information on systems requirements and program milestones for the tester.

5.4.3 System Engineering Management Plan

The Systems Engineering Management Plan (SEMP) governs the system engineering effort and serves as a top-level management plan. The content of the SEMP is prescribed in MIL-STD-499A and described in detail in the Defense System Management College Systems Engineering Management Guide. The SEMP consists of three parts: Technical Program Planning and Control, System Engineering Process, and Engineering Specialty Integration.

The SEMP is supported by a number of specialty plans that describe activities in specific areas (e.g., Integrated Logistics Support Plan and Test and Evaluation Master Plan). Program Managers and test managers need to make extensive use of the SEMP when developing and updating the TEMP.

Care should be exercised to avoid inconsistencies between the SEMP and the TEMP. Technical performance measurement parameters stated in the SEMP should be the same as those in the TEMP. To prevent inconsistencies, and ensure that the tester's needs are addressed, the Program Manager should coordinate Requests for Proposals with test managers before the RFPs are released.

5.4.4 Integrated Logistics Support Plan

Integrated Logistics Support (ILS) is a composite of all support considerations necessary to assure the effective and economical support of a system at all levels of maintenance for its programmed life cycle (Reference 64). The Integrated Logistics Support Plan (ILSP) describes the overall ILS program and includes ILS requirements, tasks, and milestones for the current and succeeding phases of the program. The ILSP serves as the source document for ILS input to other program documentation such as the Test and Evaluation Master Plan.

Standards and procedures for logistic support analysis are documented in MIL-STD-1388-1A. This standard requires that test and evaluation programs be planned to serve the following three logistics supportability objectives:

(1) Provide measured data for input into system level estimates of readiness, operational costs, and logistics support resource requirements;

(2) Expose supportability problems so that they can be corrected prior to deployment; and

(3) Demonstrate contractor compliance with quantitative supportability - related design requirements.

Development of an effective T&E program requires close coordination of efforts among all system engineering disciplines, especially those involved in logistics support analyses. The ILSP should be developed prior to Milestone I to provide a skeletal framework for logistics support analysis and to identify initial logistics testing requirements that can be used as input to the Test and Evaluation Master Plan to support ILS development.

5.5 TEST PROGRAM DOCUMENTATION

5.5.1 Test and Evaluation Master Plan

The Test and Evaluation Master Plan (TEMP) is the basic planning document for all T&E related to a particular major system acquisition. It is prepared by the Program Management Office with the operational test information provided by the Service Operational Test Organization. It is used by OSD and the Services for planning, reviewing, and approving T&E programs and provides the basis and authority for all other detailed T&E planning documents. The TEMP identifies all critical technical characteristics and operational issues and describes the objectives, responsibilities, resources, and schedules for all completed and planned T&E. The TEMP is required by DoD Directive 5000.3; guidelines for its preparation are found in DoD 5000.3-M-1.

The TEMP is a living document that must address all changes to critical issues associated with an acquisition program. Major changes in program requirements, schedule, or funding usually result in a change in the test program. Thus, the TEMP must be reviewed, and updated on an annual basis and prior to each milestone decision, to ensure that T&E requirements are current. The TEMP is the primary document used in the OSD review and decision process to assess the adequacy of planned testing and evaluation. As such, the TEMP must be of sufficient scope and content to explain the entire T&E program. The key topics in the TEMP are shown in Figure 5-2.

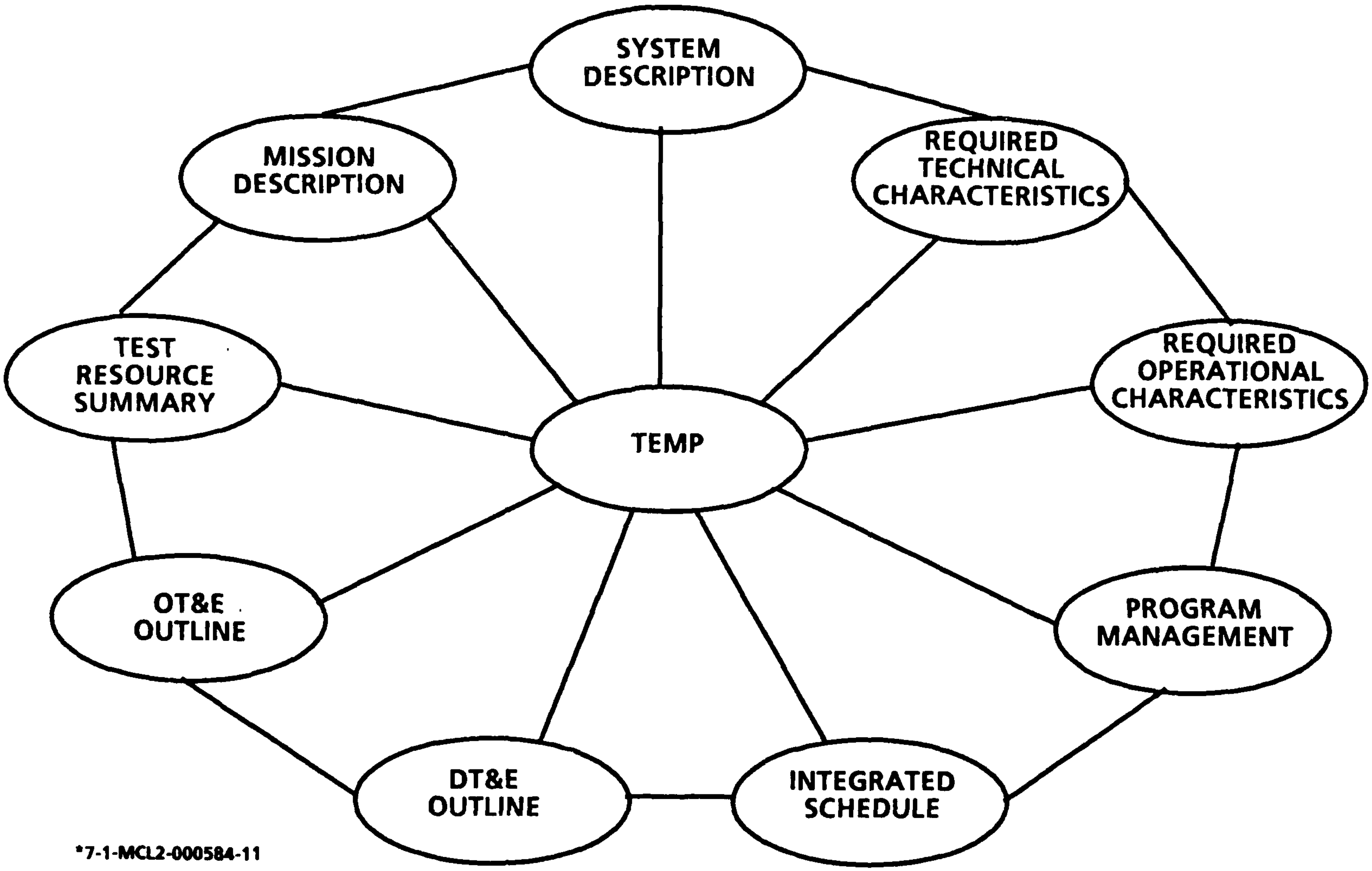


Figure 5-2. Key Elements of TEMP

Each TEMP submitted to OSD should be a summary document, detailed only to the extent necessary to show the rationale for the type, amount, and schedules of the testing planned. It must relate the T&E effort clearly to technical risks, operational issues and concepts, system performance, reliability, availability, maintainability, logistic objectives and requirements, and major decision points. It should summarize the testing accomplished to date and explain the relationship of the various simulations, subsystem tests, integrated system development tests and initial operational tests which, when analyzed in combination, provide confidence in the system's readiness to proceed into the next acquisition phase. The TEMP must address the T&E to be accomplished in each program phase, with the next phase addressed in the most detail. The TEMP is also used as a coordination document to outline each test and support organization's role in the T&E program and identify major test facilities and resources. TEMPs supporting the production and initial deployment decision must include the T&E planned to verify the correction of deficiencies and to complete production qualification testing and follow-on OT&E.

The objective of the OSD TEMP review process is to ensure successful test and evaluation programs that will support decisions to commit resources at major milestones. The T&E procedures considered during the TEMP review process are:

(1) Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) are initiated early to assess and reduce risks and estimate operational potential.

(2) Critical issues, test directives, and evaluation criteria are related to mission need and established well before testing begins.

(3) Provision is made for the collection of sufficient test data with appropriate test instrumentation to minimize subjective judgment.

(4) OT&E is conducted by an organization independent of the developer and user.

(5) The test methodology and instrumentation provide a mature and flexible network of resources that stress (as early as possible) the weapon system in a variety of realistic environments.

5.5.2 Evaluation Plan

The Navy and Air Force include evaluation planning within the test plan. The Army develops a separate plan which is used to specify the evaluation and analysis techniques that will be required once the test data has been collected and processed. The Evaluation Plan is closely linked to the Test Design, especially the statistical models on which the Test Design is built.

The Army requires the development of an "Independent Evaluation Plan" by both a technical independent evaluator and an operational independent evaluator.

The objective of the Army's Independent Evaluation Plan, according to AR 70-10, is to "address the issues; describe the evaluation of issues which require data from sources other than test; state the technical or operational issues and criteria; identify data sources; state the approach to the independent evaluation; specify the analytical plan and identify program constraints." (Reference 54)

Evaluation plans are prepared for all systems in development by the operational evaluators, during concept exploration, in coordination with the system developer. The Army Master Evaluation Plan becomes an annex to the TEMP and is updated when the TEMP is revised. It identifies each evaluation issue and the methodology to be used to assess it, and specifies requirements for exchange of information between the development/operational testers and materiel developers.

5.5.3 Test Design Plan

Of critical importance to test designers for "major" tests is to ensure that the test is constructed to provide useful information in all areas/aspects which will lead to an assessment of the system performance. For example, a complicated, even ingenious, test which does not provide the information required by the decision makers, is in many respects, a failed endeavor. Therefore, the process of developing a "Test Concept" or "Test Design" [the distinction between these vary from organization to organization] should be whether the test will provide the information required by the decision makers. In other words, "are we testing the right things in the right way?"..."and are our evaluations meaningful?"

The Test Design Plan is statistical and analytical in nature and should perform the following functions:

(1) Structure and organize the approach to testing in terms of specific test objectives;
(2) Identify key measures of effectiveness (MOEs);
(3) Identify the required data and demonstrate how the data will be gathered, stored, analyzed, and used to satisfy the MOEs;
(4) Indicate whether modeling and simulation will help in meeting test objectives; and
(5) Identify the number and type of test events.

The Test Design serves as a foundation for the more detailed Test Plan and specifies the test objectives, test events, instrumentation, test methodology, data requirements, data management needs and analysis requirements.

5.5.4 Test Plan

The Test Plan is the vehicle that translates a test concept and statistical/analytical test design into concrete resources, procedures, and responsibilities. The size and complexity of a test program and its associated test plan are determined by the nature of the system being tested and the type of testing that is to be accomplished. Some major weapons systems may require large numbers of separate tests to satisfy test objectives, and thus require a multi-volume Test Plan, while other testing may be well defined by a relatively brief Test Plan. The test plan also provides a description of the equipment configuration and known limitations to the scope of testing. The type of information typically included in a Test Plan is shown in Table 5-1.

5.5.5 Outline Test Plan/Test Program Outline

The Army's Outline Test Plan (OTP) and Air Force's Test Program Outline (TPO) are essential test planning documents. These documents are formal resource documents that specify the resources that will be required to support the test. It is important that these documents be kept current to reflect maturing resource requirements as the test program develops, since the OTP or TPO provides the means for programming the necessary resources. The Navy makes extensive use of the TEMP to document T&E resource requirements.

5.5.6 Test Reports

5.5.6.1 Quick-Look Reports

Quick-look analyses are expeditious analyses performed during testing using parts of data set. Such analyses are often used to assist in the management of test operations. Quick-look reports are occasionally used to inform higher authorities of test results. Quick-look reports may have associated briefings that present T&E results and substantiate conclusions or recommendations. Quick Look reports may be generated by the contractor or government agency. They are of particularly critical interest for high visibility systems which may be experiencing some development difficulties.

5.5.6.2 Final Test Report

The Final Test Report disseminates the test information to decision authorities, program office staff, and the acquisition community.

TABLE 5-1 Sample Test Plan Contents

PRELIMINARY PAGES

i. TITLE PAGE
ii. ABSTRACT
iii. TABLE OF CONTENTS
iv. TERMS AND ABBREVIATIONS
v. *RELATED DOCUMENTS

*THE ACTUAL NUMBER OF THESE PAGES WILL BE DETERMINED BY THE LENGTH OF PRELIMINARY ELEMENTS (e.g., TABLE OF CONTENTS, TERMS AND ABBREVIATIONS, ETC.).

MAIN BODY

1. INTRODUCTION
2. TEST PURPOSE AND OBJECTIVES
3. CONCEPT OF TEST OPERATIONS
4. METHOD OF ACCOMPLISHMENT
5. TEST SCHEDULE
6. TEST MANAGEMENT AND ORGANIZATION
7. RESPONSIBILITIES/SUPPORT
8. PERSONNEL
9. REQUIRED TEST REPORTS
10. SAFETY
11. SECURITY
12. INFORMATION
13. ENVIRONMENTAL PROTECTION

ANNEXES

A. TEST DESIGN
B. DATA REQUIREMENTS
C. INSTRUMENTATION PLAN
D. LOGISTICS SUPPORT REQUIREMENTS
E. RELIABILITY AND MAINTAINABILITY DATA PLAN
F. INTELLIGENCE/THREAT INFORMATION
G.-Z. AS REQUIRED

1, 2, 3, ETC. DETAILED TEST PROCEDURES (NAME OF TEST)

DISTRIBUTION:

Source: "Standard Procedures for USAF OT&E," July, 1974.

*7-1-MCL2-000584-10

It provides a permanent record of the execution of the test and its results. The Final Test Report should relate the test results to the critical issues and address the objectives stated in the Test Design and Test Plan. A Final Test Report may be separated into two sections - a main section providing the essential information about test methods and results, and a second section consisting of supporting appendices to provide details and supplemental information. Generally, the following topics are included in the main body of the report:

(1) Test Purpose
(2) Issues and Objectives
(3) Method of Accomplishment
(4) Results (keyed to the objectives and issues)
(5) Discussion, conclusions, and recommendations.

Appendices of the Final Test Report may address the following topics:

(1) Detailed test description
(2) Test environment
(3) Test organization and operation
(4) Instrumentation
(5) Data collection and management
(6) Test data
(7) Data analysis
(8) Modeling and simulation
(9) Reliability, availability, and maintainability information
(10) Personnel
(11) Training
(12) Safety
(13) Security
(14) Funding
(15) Asset Disposition

The Final Test Report may contain an evaluation and analysis of the results, or the evaluation may be issued separately. The analysis tells what the results are, whereas an evaluation tells what the results mean. The evaluation builds on the analysis and generalizes from it, showing how the results apply outside the test arena. It shows what the implications of the test are and may provide recommendations. The evaluation may make use of independent analyses of all or part of the data; it may employ data from other sources and it may use modeling and simulation to generalize the results and extrapolate to other conditions. In the case of the Army, a separate Independent Evaluation Report is also prepared by both technical independent evaluators, and operational independent evaluators.

5.6 OTHER TEST-RELATED STATUS REPORTS

5.6.1 End of Test Phase Report

The Services are required by DoD Directive 5000.3 to submit to OSD copies of their formal DT&E and/or OT&E reports that are prepared at the end of each phase of DT&E or OT&E. In the case of extended test phases, interim reports must be submitted at least annually. For major defense acquisition programs, such reports must be received by the Director of Operational Test and Evaluation or the Deputy Director Defense Research and Engineering (Test and Evaluation) no later than 45 days prior to a milestone decision.

5.6.2 Low-Rate Initial Production Report

Before proceeding beyond Low-Rate Initial Production (LRIP) for each major defense acquisition program, the Director of Operational Test and Evaluation must report to the Secretary of Defense and the Senate and House of Representatives Committees on Armed Services and on Appropriations. This report addresses whether the OT&E performed was adequate, and whether the OT&E results confirm that the items or components actually tested are effective and suitable.

5.7 SUMMARY

A wide range of documentation is available to the test manager and should be used to develop test and evaluation programs that address all relevant issues. The Program Manager must work to ensure that T&E requirements are considered at the outset, when the Acquisition Strategy is formulated. He must also require early and close coordination and a continuing dialogue among those responsible for the Systems Engineering Management Plan, the Integrated Logistics Support Plan, and the Test and Evaluation Master Plan.

CHAPTER 6
NONDEVELOPMENT ITEMS

6.1 INTRODUCTION

Many options are available when an acquisition strategy for a new system is chosen. They range from a traditional new research and development program to the use of "off-the-shelf" nondevelopment items (NDI). Between these two extremes lie other acquisition strategies that call for using nondevelopment items to various extents. Figure 6-1, an adaptation of an illustration found in Army Materiel Command Pamphlet 70-2, shows the broad spectrum of approaches that can be taken in a system acquisition and provides examples of systems that have been developed using each approach.

6.1.1 Definition of NDI

NDI refers to materiel available from a variety of sources, but involving little or no development effort. It includes commercial products, materiel developed by other U.S. Government sources, or materiel developed in other countries. All such systems are required to undergo technical and operational T&E prior to the procurement decision, unless a definitive decision is made by the decision authority, that previous testing or other data (such as user/market investigations) provide sufficient evidence of acceptability (Reference 54.)

6.1.2 Advantages and Disadvantages of the NDI Approach

The use of NDI offers the following advantages:

- The time to field a system is greatly reduced, and a quick response is provided to the user's needs;
- Research and development costs are reduced; and
- State-of-the-art technology is available immediately.

NDI offers the following disadvantages:

- NDI acquisitions are difficult to standardize with the current fleet equipment;
- NDI acquisitions create logistics support difficulties;
- NDI acquisitions tend to not have competition and therefore, the availability of second source is not present; and

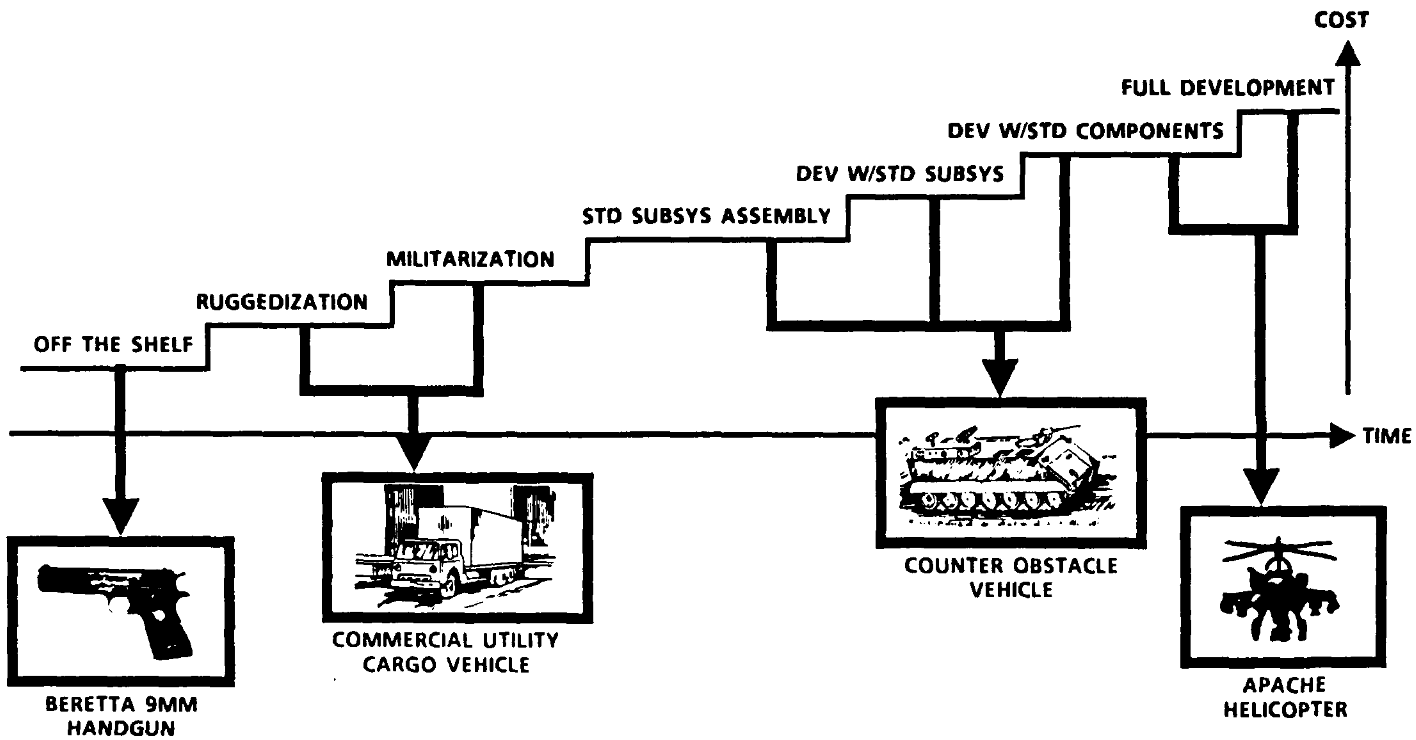


Figure 6-1. The Spectrum of Acquisition Strategies

SOURCE: ARMY MATERIAL COMMAND PAMPHLET 70-2, "AMC-TRADOC MATERIEL ACQUISITION HANDBOOK," 26 MARCH 1987.

*7-1-MCL2-000584-02

o With NDI acquisitions engineering and test data is often not availabe.

6.1.3 Types of NDI

Nondevelopment items can be separated into two general categories; each requires a modified testing approach. The categories are:

(1) Off-the-shelf items for use in the same environment for which the items were designed. Such items normally do not require development testing prior to the production qualification test except in those cases where a contract may be awarded to a contractor who has not previously produced an acceptable finished product and the item is assessed as high risk. In that case, preproduction qualification testing would be required (Reference 54.)

(2) Off-the-shelf items for use in an environment other than that for which the items were designed. Such items may require modifications in hardware and/or software. These items require testing in an operational environment, preproduction qualification testing (if previous testing resulted in item redesign), and production qualification testing.

Existing components that must be integrated with a new system configuration may be purchased off the shelf. These would not be classified as a NDI but many of the testing and evaluation methods would still apply. This type of NDI effort requires more extensive research, development, and testing to achieve the desired system configuration. Testing required includes: feasibility testing in a military environment; preproduction qualification testing; hardware/software integration testing; operational testing; and production qualification testing.

Given the variety of NDI approaches that may be employed, it is imperative that the acquisition strategy clearly specify, with the agreement of the testing authority, the level of testing that will be performed on NDI systems and the environment those systems will be tested in.

6.2 MARKET INVESTIGATION AND PROCUREMENT

A market investigation is the central activity leading to the milestone I review decision regarding the use of an NDI acquisition strategy. The purpose of the market investigation is to determine the nature of available products and the number of potential vendors. Market investigations may vary from informal telephone inquiries to comprehensive industry - wide reviews. During the market investigation, sufficient data must be gathered to support a definitive NDI decision, to finalize the requirements, and to develop an acquisition strategy that is responsive to these requirements.

During the market investigation phase, a formal "request for information" process may be followed wherein a brief narrative description of the requirement is published and interested vendors are invited to respond. Test samples or test items may be leased or purchased at this time to support the conduct of operational suitability tests, to evaluate the ability of the equipment to satisfy the requirements, and to help build the functional purchase description or system specification. This type of preliminary testing should not be used to select or eliminate any particular vendor or product unless it is preceded by competitive contracting procedures (Reference 61.)

It is imperative that technical and operational evaluators become involved during this early stage of an NDI procurement, that they perform an early assessment of the initial issues, relate these issues to test and evaluation criteria, and provide their independent evaluation plans and reports to the decision authorities prior to the milestone I decision review.

6.3 NDI TESTING

6.3.1 General Considerations

Test and evaluation must be considered throughout the acquisition of a system that involves NDI. The Program Manager and his staff must ensure that the testing community is fully involved in the acquisition from the start. The amount and level of testing required depends on the nature of the NDI and its anticipated use and should be planned to support the design and decision process. Available test results from all commercial and Government sources will determine the actual extent of testing necessary. There are some inherent advantages in NDI testing. For example, a NDI usually encompasses a mature design. The availability of this mature design contributes to the rapid development of the logistics support system that will be needed. In addition, there are more "production" items available for use in a test program. The Program Manager and his staff must bear in mind that NDI systems also require activity in areas associated with traditional development and acquisition programs. For example, training and maintenance programs and manuals must be developed and sufficient time should be allowed for their preparation.

When the solicitation package for an NDI acquisition is assembled, the Program Manager must ensure that it includes the following T&E-related items:

(1) Approved test and evaluation issues and criteria;

(2) A requirement that the offeror provide a description of the testing performed by the contractor on the system, including test procedures followed, test data, and results achieved;

(3) Production Qualification Test and Quality Conformance Requirements; and

(4) Acceptance test plans for the system and its components.

6.3.2 Testing Before Milestone I

An important advantage of using an NDI acquisition strategy is reduced acquisition time. Consequently, it is important that testing not be redundant and that it is limited to the minimum effort necessary to obtain the required data. Testing can be minimized by:

(1) Obtaining and assessing contractor test results;

(2) Obtaining usage/failure data from other customers;

(3) Observing contractor testing;

(4) Obtaining test results from independent test organizations (e.g., Underwriter's Laboratory); and

(5) Verifying selected contractor test data.

If after the initial data collection from the above sources, it is determined that more information is needed, NDI candidates may be bought or leased and technical and operational tests may be conducted.

6.3.3 Testing After Milestone I

All testing to be conducted after the initial milestone decision to proceed with the NDI acquisition should be described in the Decision Coordinating Paper and the Test and Evaluation Master Plan. Technical testing is conducted only if specific information is needed that cannot be satisfied by contractor or other test data sources. Operational testing is conducted as needed. The independent operational test and evaluation agency should concur in any decisions to limit or eliminate operational testing.

Test and evaluation continues even after the system has been fielded. This testing takes the form of a follow-on evaluation to validate and refine: operating and support cost data; reliability, availability, and maintainability characteristics; logistic support plans; and training requirements, doctrine and tactics.

6.4 RESOURCES AND FUNDING

Programming and budgeting for an NDI acquisition present a special challenge. Because of the short duration of the NDI acquisition process, the standard lead times required in the normal Planning, Programming, and Budgetary System (PPBS) cycle may be unduly restrictive. This situation can be minimized through careful advanced planning and, in the case of urgent requirements, reprogramming/supplemental funding techniques.

Research, Development, Test and Evaluation (RDT&E) funds are normally used to support the conduct of the market investigation phase and the purchase or lease of NDI candidates required for test and evaluation purposes. RDT&E funds are also used to support test and evaluation activities such as: modification of the NDI; the purchase of specifications, manufacturer's publications, repair parts, special tools and equipment; the transportation of the NDI to and from the test site; and the training, salaries and temporary duty (TDY) costs of test and evaluation personnel. Procurement and Operations and Maintenance funds are usually used to support production and deployment costs.

One of the chief advantages of using an NDI acquisition strategy is reduced overall cost. Additional cost savings can be achieved after a contract has been awarded if the Program Manager ensures that incentives are provided to contractors to submit value engineering change proposals to the Government when unnecessary costs are identified.

6.5 SUMMARY

The use of nondevelopment items in a system acquisition can provide considerable savings in both time and cost. The testing approach used for an NDI acquisition must be carefully tailored to the type of system and the amount of test data already available. The test and evaluation community must get involved early in the process so that all test issues are adequately addressed and timely comprehensive evaluations are provided to decision authorities.

MODULE II

DEVELOPMENT TESTING

Materiel acquisition is an iterative process of design, build, test, identify deficiencies, fix, retest, and repeat. Development Test and Evaluation (DT&E) is an important aspect of this process. The DT&E is performed in the factory, laboratory and on the proving ground by the subcontractors as they are developing the components and subassembly, by the prime contractor as he assembles the components and ensures integration of the system, and by the Government to demonstrate how well the weapon system meets its technical and operational requirements. This module describes development testing and the various types of activities it involves. The module also discusses how development testing is used to support the technical review process.

CHAPTER 7

INTRODUCTION TO DEVELOPMENT TEST AND EVALUATION

7.1 INTRODUCTION

Development test and evaluation is that test and evaluation conducted to demonstrate that the engineering design and development process is complete. It is used by the contractor to reduce risk, validate and qualify the design and to ensure that the product is ready for government acceptance. DT&E results are evaluated to ensure that design risks have been minimized, that the system will meet specifications, and to estimate the system's military utility when it is introduced into service. DT&E also serves a critical purpose in reducing the risks of development by testing selected high risk components or subsystems. Finally, DT&E is the government Developing Agency (DA) tool to confirm that the system performs as technically specified, and that the system is ready for field testing. This chapter provides a general discussion of contractor and Government DT&E activities, stresses the need for an integrated test program, describes some special purpose types of DT, and discusses several factors that may influence the extent and scope of the DT&E program.

7.2 DT&E RESPONSIBILITIES

As illustrated in Figure 7-1, the primary participants in testing are the prime contractor, subcontractor, Service materiel developer or developing agency and the operational test and evaluation agency. In some Services, there are also independent evaluation organizations that assist the testing organization in the design and evaluation of development tests. As the figure shows, system development testing is performed principally by contractors during the early development stages of the acquisition cycle and government test/evaluation organizations during the later phases.

The Army testing of the Advanced Attack Helicopter illustrates the type of development testing performed by contractors and the relationship of this type of testing to government DT&E activities.

> During the contractor competitive Phase I testing of the Army's Advance Attack Helicopter (AAH), the prime and subcontractor's testing included design support tests, testing of individual components, establishing limited fatigue lives, and bench testing of dynamic components to demonstrate sufficient structural integrity for the conduct of the Army competitive flight test program. Complete dynamic system testing was conducted utilizing ground test vehicles. In

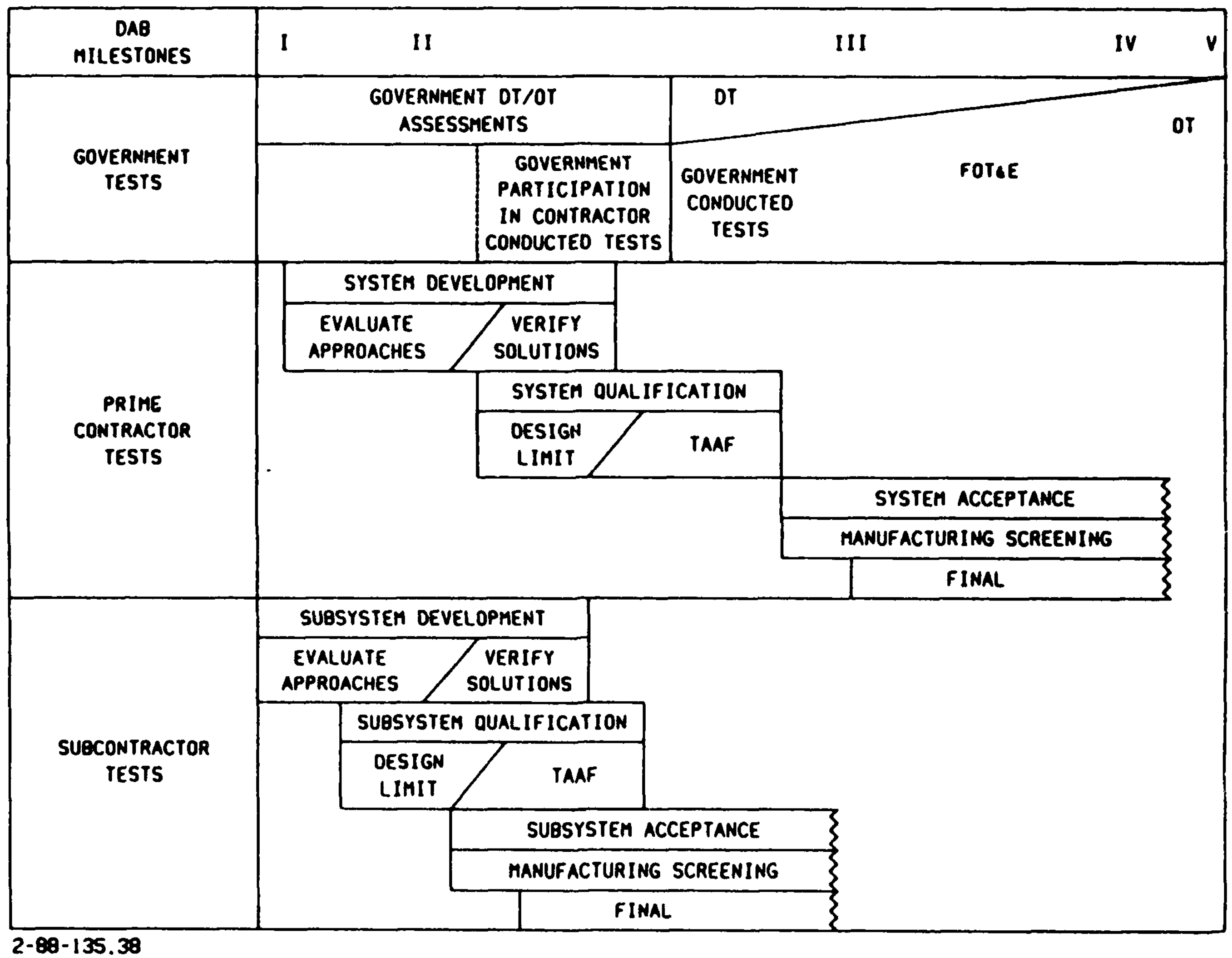


Figure 7-1. Integrated Test Requirements

Source: Adapted & Modified from, "Solving the Risk Equation in Transiting From Development to Production," January 19, 1984 addition to supporting the contractor's development effort, these tests also provided information for the Army's technical review process as the Systems, Preliminary and Critical Design Reviews were conducted. Following successful completion of the Ground Test Vehicle Qualification Testing, first flights were conducted on the two types of competing helicopters with each aircraft being flown 300 hours before delivery of two of each competing aircraft to the Army. The contractor flight testing was oriented toward flight envelope development, demonstration of structural integrity, and evaluation and verification of aircraft flight handling qualities. Some weapons system testing was conducted during this phase. During this phase, government testers used much of the contractor's testing data to develop the test data matrix as part of the government's DT and OT planning efforts. The use of contractor's test data reduced the testing required by the Government, and added validity to the systems test already conducted and data received from other sources.

7.2.1 Contractor Testing

Materiel development, testing, and evaluation is an iterative process in which a contractor designs hardware and software, evaluates its performance, makes changes as necessary and retests for performance and technical compliance. Contractor testing plays a primary role in the total test program, and the results of contractor tests are useful to the Government evaluator in supporting Government test objectives. It is important that Government evaluators oversee, as appropiate, contractor system tests and use test data from them to address the issues for Government testing. It is not uncommon for contractor testing to be conducted at Government test facilities, since contractors often do not have the required specialized facilities (e.g., for testing hazardous components or for missile flight tests). This enables Government evaluators to monitor the tests more readily and increases Government confidence in the test results.

Normally, a Request For Proposal (RFP) requires that the winning contractor submit an Engineering Design Test Plan within sixty to ninety days after contract initiation for coordination with Government test agencies and approval. When approved, the contractor's test program automatically becomes part of the Development Agency's Integrated Test Plan.

If the contractor has misinterpreted the RFP requirements and the Engineering Design Test Plan does not satisfy the Government test objectives, the iterative process of amending the contractor's test program begins. This iterative process must be accomplished within limited bounds so that the contractor can meet the test objectives without significant effects on contract cost, schedule, or scope.

7.2.2 Government Testing

Government testing is performed to demonstrate how well the materiel system meets its technical compliance requirements; to provide data to assess developmental risk for decision making; to verify that the technical, and support problems identified in previous testing have been corrected; and to ensure that all critical issues to be resolved by testing have been adequately considered. All previous testing is considered during the Government evaluation from the contractor's bench testing through Development Agency testing of production representative prototypes.

Government materiel development organizations include major materiel acquisition commands and, in some cases, operational commands. The materiel acquisition commands have test and evaluation organizations that conduct government development testing. In addition to monitoring and participating in contractor testing, these organizations conduct development testing on selected high concern areas to evaluate the adequacy of systems engineering, design, development and performance to specifications. The Program Management Office must be involved in all stages of the testing these organizations perform.

In turn, the Materiel Development/Test and Evaluation Agencies conduct test and evaluation of the systems in the development stage to ensure that they meet technical and operational requirements. These organizations operate Government proving grounds, test facilities and labs and must be responsive to the needs of the Program Manager by providing test facilities, personnel, and data acquisition services as required.

7.2.3 Program Manager's Role

The Program Manager is responsible for coordinating the test and evaluation program. He performs this task with the assistance of the test and evaluation working group whose members are assembled from development agency and combat development, technical and operational test and evaluation, logistics, and training organizations. The Program Manager must remain active in all aspects of testing including planning, funding, resourcing, execution and reporting. He plays an important role as the interface between the contractor and the government testing community. Recent emphasis on early T&E highlights a need for early government tester involvement in contractor testing. For example, during development of the Army Advanced Attack Helicopter (AAH) test, it was found that having Program Management personnel on the test sites improved test continuity, facilitated the flow of spares and repair parts, provided a method of monitoring the contractor's performance, and kept the Services informed with timely status reports.

7.3 TEST PROGRAM INTEGRATION

During the development of a weapon system, there are a number of tests that are conducted by subcontractors, the prime contractor, and the Government. To ensure that these tests are properly time phased, that adequate resources are available, and to minimize unneccessary testing, a coordinated test program must be developed and followed. The Test and Evaluation Master Plan (TEMP) normally addresses government-conducted tests only; it does not provide a sufficient level of detail concerning contractor or subcontractor tests. A contractor or PMO Integrated Test Plan must also be developed to describe these tests.

7.3.1 Integrated Test Plan

The Integrated Test Plan (ITP) is used to record the individual test plans for the subcontractor, prime contractor, and Government. The prime contractor should be contractually responsible for the preparation and updating of the ITP, and the contractor and Service Developing Agency should ensure that it remains current. The ITP includes all developmental tests which will be performed by the prime contractor and the subcontractors at both the system and subsystems levels. It is a detailed working-level document which assists in identifying risk, as well as duplicative or missing test activities. A well-maintained ITP facilitates the most efficient use of test resources.

7.3.2 Single Integrated Test Policy

Most Services have adopted a single integrated test policy, thereby reducing much of the government testing requirements. This policy stresses independent government evaluation, permits an evaluator to monitor both contractor and government test programs, and evaluate the system from an independent perspective. The policy stresses the use of all available test data for system evaluation.

7.4 AREAS OF DT&E FOCUS

7.4.1 Life Testing

Life Testing is performed to assess the effects of long-term exposure to various portions of the anticipated environment . These tests are used to ensure that the system will not fail prematurely due to metal fatigue, component aging, or other problems caused by long term exposure to environmental effects. It is important that the requirements for life testing are identified early and integrated into the system test plan. Life tests are time consuming and costly; therefore, life testing requirements and life characteristics must be carefully analyzed concurrent with the initial test design. Aging failure data must be collected early and analyzed throughout the testing cycle. If life characteristics are ignored until results of the test are available, extensive redesign and project delays may be required. Accelerated life testing techniques are available and may be used whenever applicable.

7.4.2 Design Evaluation/Verification Testing

Design evaluation and verification testing is conducted by the contractor and/or the development agency with the primary objective of influencing system design. Design evaluation is fully integrated into the development test cycle and its purposes are to:

(1) Determine if critical system technical characteristics are achievable;
(2) Provide data for refining and making the hardware more rugged so it will comply with technical specification requirements;
(3) Eliminate as many technical and design risks as possible or to determine the extent to which they are manageable;
(4) Provide for evolution of design and verification of the adequacy of design changes;
(5) Provide information in support of development efforts; and
(6) Ensure components, subsystems, and systems are adequately developed before beginning Operational Test (OT).

7.4.3 Design Limit Testing

Design limit tests are integrated into the test program to ensure that the system will provide adequate performance when operated at the outer performance limits and when exposed to environmental conditions expected at the extreme of the operating envelope. The tests are based on mission profile data. Care must be taken to ensure that all systems and subsystems are exposed to the worst case environments with adjustments made because of stress amplication factors and cooling problems. Care must also be taken to ensure that the system is not operated beyond the specified design limits. For example, an aircraft component may have to be tested at temperature extremes from an artic environment to a desert environment.

7.4.4 Reliability Development Testing

Reliability Development Testing (RDT) is a planned Test, Analyze, and Fix (TAAF) process in which development items are tested under actual or simulated mission profile environments to disclose design deficiencies and to provide engineering information on failure modes and mechanisms. The purpose of RDT is to provide a basis for early incorporation of corrective actions and verification of their effectiveness in improving the reliability of equipment. RDT is conducted under controlled conditions with simulated operational mission and environmental profiles to determine design and manufacturing process weaknesses. The RDT process emphasizes reliability growth rather than a numerical measurement. Reliability growth during RDT is the result of an iterative design process because as the failures occur, the problems are identified, solutions proposed, the redesign is accomplished and the RDT continues. A substantial reliability growth TAAF testing effort was conducted on the F-18 DT&E for selected avionics and mechanical systems. Although the TAAF effort added $100 million to the RDT&E program, it is estimated that many times that amount will be saved through lower operational costs throughout the system's life.

7.4.5 Reliability, Availability and Maintainability Assessment

Reliability, Availability and Maintainability (RAM) requirements are assessed during all contractor and Government testing. Data is collected from each test event and placed in a RAM data base which is managed by the development agency. Contractor and Government development tests provide a measure of the system RAM against stated specifications in a controlled environment. The primary emphasis of RAM collection during the DT is to provide an assessment of the system's RAM growth and a basis for assessing the consequences of any differences anticipated during field operations.

7.5 SYSTEM DESIGN FOR TESTING

Built-in Test (BIT) and production testing are two major areas that must be considered from the start of the design effort. Design for testing addresses the need to: (1) collect data during the development process concerning particular performance characteristics; (2) enable efficient and economic production by providing ready access to and measurement of appropriate acceptance parameters; and (3) enable rapid and accurate assessment of the status of the product to the lowest repairable element when deployed. Many hardware systems have testing circuits designed and built-in. This early planning by design engineers allows easy test for fault isolation of circuits, both in development phases of the system development and during operational testing and deployment. There are computer chips in which more than one half of the circuits are for test/circuit check functions. This type of circuit design requires early planning by the PM to ensure that the RFP includes the requirement for designed/built-in test capability.

7.6 IMPACT OF WARRANTIES ON T&E

A warranty or guarantee is a commitment provided by a supplier to deliver a product that meets specified standards for a specified period of time. With a properly structured warranty, the contractor is required to meet technical and operational requirements. If the product should fail during the period of that warranty, the contractor must replace or make repairs at no additional cost to the Government. The Defense Appropriations Act of 1984 requires warranties or guarantees on all procurements of weapon systems. This act makes warranties a standard item on most fixed price production contracts. Incentives are the main thrust of warranties, and as prescribed in MIL-STD-781, the Government will perform a reliability demonstration test on the system to determine these incentives. Although warranties have favorable advantages to the Government during the early years of the contract, warranties do not affect the types of testing performed to ensure that the system meets technical specifications and its operational effectiveness and suitability. Warranties do, however, have an effect on the amount of testing required to establish reliability. Because the standard item is warranted, less emphasis on that portion of the item can allow for additional emphasis on other aspects of the item that are not covered under the warranty. Further, the Government may tend to have more confidence in the contractor test results and may be able, therefore, to avoid some duplication of test effort. The warranty essentially shifts the burden of performance from the Government to the contractor. Warranties can increase significantly the price of the contract, especially if high risk components are involved.

7.7 DT&E OF LIMITED PROCUREMENT QUANTITY PROGRAMS

Programs that involve the procurement of relatively few items, typically over an extended time period, are normally subjected to standard DT&E. Occasionally, a unique test approach will be used which deviates from the standard timing and reporting schedule. The principle of DT&E of components, subsystems, prototypes, and first production models of the system is normally applied to limited procurements. It is important that DT&E and OT&E organizations work together to ensure that T&E plans are integrated into the overall acquisition strategy.

7.8 SUMMARY

Development Test and Evaluation is an iterative process of design, build, test, identify deficiencies, fix, retest, and repeat. It is performed in the factory, laboratory and on the proving ground by the contractors and the Government. Contractor and Government testing is combined into one integrated program test and conducted to determine if the technical development of the acquisition process have been met, and to provide data to the decision authority.

CHAPTER 8

DT&E SUPPORT OF TECHNICAL REVIEWS AND MILESTONE DECISIONS

8.1 INTRODUCTION

Throughout the acquisition process, development test and evaluation is oriented toward the demonstration of the completeness and adequacy of systems engineering, design, development and performance to specifications. DT&E serves a critical purpose in reducing the risks of development by testing and evaluating selected high risk components or subsystems. DT&E is the developer's tool to establish the system performs as specified, deficiencies are corrected and the system is ready for operational testing and fielding. DT&E results are used throughout the system engineering process to provide valuable data in support of formal design reviews. This chapter describes the types of development testing that are used throughout the system acquisition cycle to support the materiel acquisition process. It also describes the objectives of the various tests conducted during the DT&E process and discusses their relationship to the formal design reviews that are essential to the systems engineering process.

8.2 DT&E AND THE SYSTEM ACQUISITION CYCLE

As illustrated in Figure 8-1, development test and evaluation is conducted throughout the system life cycle. DT&E begins before program initiation (milestone 0) with the evaluation of evolving technology, and continues after the system is in service, (prior to milestone V).

8.2.1 DT&E Prior to Program Initiation

Prior to program initiation, technology feasibility testing is conducted to confirm that the technology considered for the proposed weapon development is the most advanced available and that it is technically feasible.

8.2.2 DT&E During the Concept Exploration/Definition Phase

Development testing that takes place during the Concept Exploration/Definition Phase is conducted by the contractor and Government to assist in selecting preferred alternative system concepts, technologies, and designs. The testing conducted depends on the state of development of the test article's design. Government test evaluators participate in this testing because information obtained can be used to support the Systems Requirements Review. The information obtained from these tests may also be used to support a concept selection decision by the Services or OSD.

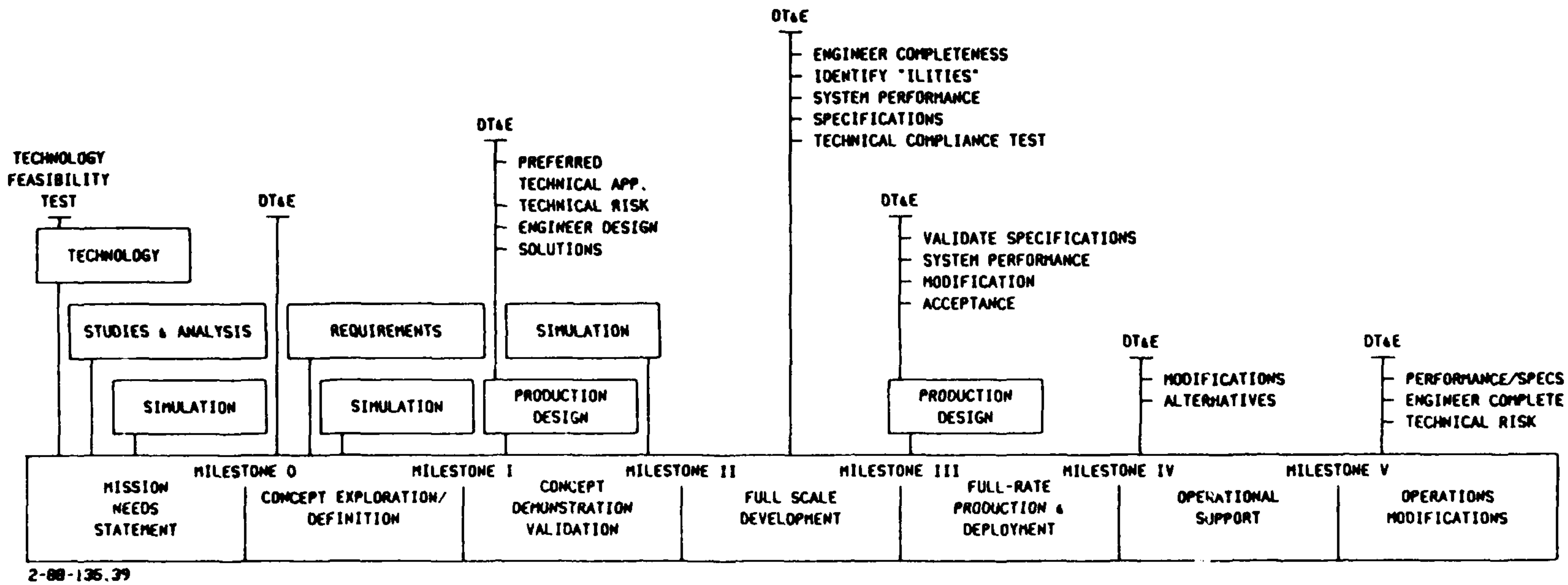


Figure 8-1. Relationship of DT&E to the Acquisition Process

8.2.3 DT&E During the Concept Demonstration/Validation Phase

Development testing conducted during the Concept Demonstration/Validation Phase is used to demonstrate: that all technical risk areas have been identified and reduced to acceptable levels; that the best technical approaches have been accepted; and that from this point on, engineering efforts, rather than experimental efforts, will be required. It supports the Milestone II decision which considers entry into Full-Scale Development and as appropriate low rate initial production. This DT&E includes: contractor/government integrated testing, engineering design testing, and advanced development verification testing.

Development testing done during this period is most often conducted at the contractor's facility. It is conducted on components, subsystems, brassboard configurations or advanced development prototypes to evaluate the potential application of technology and related design approaches prior to Full-Scale Development. Component interface problems and equipment performance capability are evaluated. The use of properly validated analysis, modeling, and simulation is encouraged, especially during the early phases to assess those areas that, for safety or testing capability limitations, cannot be directly observed through testing. Models can provide early projections of systems performance, effectiveness and suitability and can reduce testing costs. This test and evaluation also includes an initial environmental assessment.

The Army's testing of the Advanced Attack Helicopter provides an example of the type of activities that occur during DT. The early DT&E on the Advanced Attack Helicopter (AAH) was conducted by the Army Engineering Flight Activity. The test was conducted in conjunction with an Early Operational Test, and candidate designs were flown more than 90 hours to evaluate flight handling qualities and aircraft performance. This test also included the firing of the 30 millimeter cannon and the 2.75 inch rockets. RAM data was obtained throughout the test program and this data, along with RAM data provided from early contractor testing, became a part of the system's RAM database. After evaluating the results, the Army selected a contractor to proceed with Full-Scale Development of the AAH.

8.2.4 DT&E During the Full-Scale Development Phase

DT&E conducted during the Full-Scale Development Phase provides the final technical data for determining a system's readiness to transition into either low-rate initial production or full-rate production. It is conducted using prototype hardware and is characterized by the use of engineering and scientific approaches under controlled conditions. The test provides quantitative and qualitative data for use in the system's evaluation. The evaluation results are used by the development community and are also provided to Service and OSD decision authorities. This test measures technical performance including: effectiveness, reliability, availability, maintainability, compatibility, interoperability, safety, and supportability. It includes tests of human engineering and technical aspects of the system and demonstrates whether engineering is reasonably complete and whether solutions to all significant design problems are in hand.

As an example of testing done during the full-scale development phase the Army Advanced Attack Helicopter was flown in a series of Engineering Design Tests (EDT). The EDT-1, 2, and 4 were flown at the contractor's facility. (The EDT-3 requirement was deleted during a program restructuring). The objectives of these flight tests were to evaluate the handling characteristics of the aircraft, check significant performance parameters and confirm the correction of deficiencies noted during earlier testing. The EDT-5 was conducted at the Army's test facility, Yuma Proving Ground. The objectives of this test were the same as earlier EDTs; however, the testers were required to ensure that all discrepancies were resolved prior to the aircraft going into operational testing. During the EDT's, operational test personnel were completing Operational Test, test design, bringing together test resources and observing the DT&E tests. Additionally, OT personnel were compiling test data from other sources, such as the system contractor's test results. The evolving DTtest results, along with contractor data, were made available to the Critical Design Review members to ensure that each configuration item design was essentially completed. Additionally, a Physical Configuration Audit was conducted by the Army to provide a technical examination to verify that each item "as built" conformed to the technical documentation which defined that item.

8.2.5 DT&E During the Full-Rate Production/Deployment Phase

Development testing may be conducted throughout the LRIP phase or after the full-rate production decision is made at Milestone III. This test is normally tailored to identify design problems and demonstrate the system's readiness for production. This testing is conducted under controlled conditions and provides quantitative and qualitative data. The test primarily addresses technical performance problems and the "ilities": Reliability, Maintainability, Survivability, and Availability. This testing is conducted on production prototypes of production items delivered from either the pilot or initial production runs. It is conducted to verify the system's adequacy and quality when it is produced in quantity. The test ensures that the items are produced according to contract specification, using quantity production processes. This test determines whether the system is successfully transitioning from engineering development prototype to production and that the system meets design specifications. The testing performed during this phase includes testing to confirm corrections made as a result of the evaluation of problems disclosed during previous development testing.

8.2.6 Post Production T&E

The development testing that occurs soon after the initial Operating Capability or initial deployment assesses the deployed system's operational readiness and supportability. It ensures that all of the deficiencies noted during previous testing have been corrected, evaluates proposed product improvements and block upgrades, and ensures that integrated logistics support is complete. It also evaluates the resources on hand and the plans to ensure operational phase readiness and support objectives are sufficient to achieve and maintain the system for the remainder of its acquisition life cycle. Near the end of the system's life, DT&E is performed to assist in modification of the system to help meet new threats of technologies and to aid in disposal.

Once a system approaches the end of its usefulness, the development testing conducted at that stage is concerned with the monitoring of a system's current state of operational effectiveness, suitability, and readiness to determine whether major upgrades are necessary or deficiencies warrant consideration of total system replacement. Tests are normally conducted by the Operational Testing community; however, the T&E community may be required to assess the technical aspects of the system.

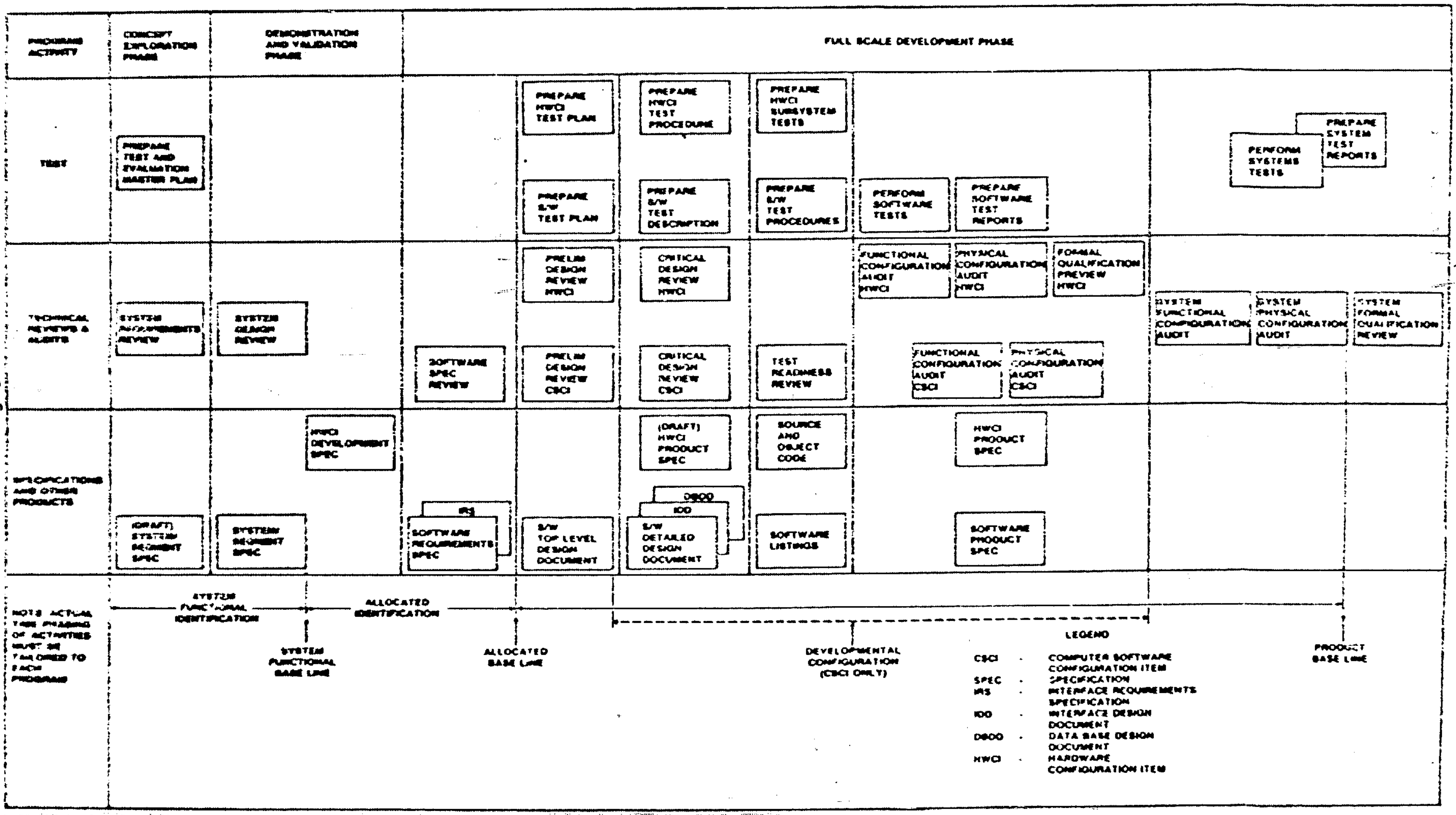
8.3 DT&E AND THE REVIEW PROCESS

8.3.1 The Technical Review Process

Technical reviews and audits are conducted by the Government and the contractor as part of the system engineering process to ensure the design meets the system, subsystem and software specifications. Each review is unique in its timing and its orientation. Some reviews build on previous reviews and take the design and testing effort one step closer to the final system design to satisfy the operational concept/purpose for the weapon system. Figure 8-2 illustrates the sequencing of the technical reviews in relation to the test and evaluation phases.

The review process was established to ensure that the system under development would meet the government's requirements. The reviews evaluate data from contractor and government testing, engineering analysis, and models to determine if the system or its components will eventually have the ability to meet all functional and physical specifications and to determine the final system's design. The system specification is very important in this process. It is the document used as a benchmark to compare contractor progress in designing and developing the desired product. The requirements and direction for these formal technical reviews and audits are set forth in MIL-STD-1521B.

DESIGN REVIEWS



8.3.2 Testing in Support of Technical Reviews

The testing community must be continually involved in the technical reviews of their systems. Decisions made at these reviews have major impacts on the system test design, resources required to test, and the development of the TEMP and other documentation. A more detailed discussion of testing to support the Technical Reviews is provided in the Systems Engineering Management Guide (Reference 45). The reviews focus primarily on the Government's technical specifications for the system. Figure 8-3 illustrates the program specifications and how they are developed in the system life cycle.

8.3.3 Formal Reviews

8.3.3.1 Systems Requirements Review (SRR)

The SRR is normally conducted during the System Concept Exploration or Demonstration/Validation Phases. It consists of a review of the system/system segment specifications, also known as the "A" specifications (System Functional Block Diagram, Reference 45, Chapter 12), and is conducted after the accomplishment of functional analysis and preliminary requirements allocation. During this review, the systems engineering management activity and its output are reviewed for responsiveness to the Statement of Work requirements. The primary function of the SRR is to ensure that systems requirements have been completed and properly identified and that there is a mutual understanding between the contractor and the Government. During the review, the contractor describes his progress and any problems in risk identification and ranking, risk avoidance and reduction, trade-off analysis, producibility and manufacturing considerations, and hazards considerations. The results of integrated test planning are reviewed to ensure the adequacy of planning to assess the design and to identify risks.

8.3.3.2 Systems Design Review (SDR)

The SDR is conducted as a final review prior to submittal of the Concept Demonstration/Validation Phase products or as the initial Full-Scale Development Review. The "A" specification is validated to ensure that the most current specification is included in the System Functional Baseline and that they are adequate and cost effective to satisfy validated mission requirements. The SDR encompasses the total system requirement of operations, maintenance, test, training, computers, facilities, personnel and logistics considerations. A technical understanding should be reached on the validity and the degree of completeness of the specifications, design, operational concept documentation, software requirements specifications and interface requirements specifications during this review.

SPECIFICATION	WHEN PREPARED	PREPARING AGENT	APPROVING AGENT	CONTENT	BASE-LINE
SYSTEM/SEGEMENT (TYPE A)	CE PHASE	DEV/PROG MGR INDUSTRY	DEV/PROG MGR USER	DEFINE MISSION AND TECH REQMTS; ALLOCATES REQUIRE-MENTS TO FUNCTIONAL AREAS; DOCUMENTS DESIGN CONSTRAINTS; DEFINES INTERFACES	FUNC-TIONAL
DEVELOPMENT (TYPE B, PART I, DESIGN-TO)	LATE D/V PHASE	INDUSTRY	DEV/PROG MGR	DETAILS DESIGN REQUIREMENTS; STATES DESCRIBES PERFORMANCE CHARACTERISTICS OF EACH CI; DIFFERENTIATES REQUIREMENTS ACCORDING TO COMPLEXITY AND DISCIPLINE SETS	ALLO-CATED
PRODUCT (TYPE C, PART II, BUILD-TO)	LATE FSD PHASE	INDUSTRY	DEV/PROG MGR	DEFINES FORM, FIT, FUNCTION, PERFORMANCE, AND TEST REQUIREMENTS FOR ACCEPTANCE	PRODUCT
PROCESS (TYPE D)	FSD/PROD PHASES	INDUSTRY	DEV/PROG MGR	DEFINES PROCESS PERFORMED DURING FABRICATION	
MATERIAL (TYPE E)	FSD/PROD PHASES	INDUSTRY	DEV/PROG MGR	DEFINES PRODUCTION OF RAW OR SEMI-FABRICATED MATERIAL USED IN FABRICATION	

Figure 8-3. Specifications Summary
Source. Systems Engineering Management Guide

8.3.3.3 Software Specification Review (SSR)

The SSR is a formal review of the Computer System Configuration Item (CSCI) requirements, normally held after a SDR but prior to the start of a CSCI preliminary design. Its purpose is to validate the allocated baseline for preliminary CSCI design by demonstrating to the government the adequacy of the Software Requirements Specifications, Interface Requirements Specifications, and Operational Concept Documentation.

8.3.3.4 Preliminary Design Review (PDR)

The PDR is a formal technical review of the basic approach for a configuration item. It is conducted at both the configuragtion item and system level early in the Full-Scale Development Phase to confirm that the preliminary design logically follows the SDR findings and meets the system requirements. The review results in an approval to begin the detailed design. The Draft Type B Specifications are reviewed during the PDR. The purpose of the PDR is to: evaluate the progress, technical adequacy, and risk resolution (on technical, cost, and schedule basis) of the configuration item design approach, DT & OT activities to support the performance of each CI, and establish the existence and compatibility of the physical and functional interface among the CI and other equipment.

8.3.3.5 Critical Design Review (CDR)

The CDR may be conducted on each configuration item and/or at the system level. It is conducted during the Full-Scale Development Phase when the detailed design is essentially complete, prior to the Functional Configuration Audit. During the CDR, the overall technical program risks associated with each configuration item are also reviewed on a technical, cost and schedule basis. It includes a review of the "C" Specifications and the status of both the system's hardware and software.

8.3.4.6 Test Readiness Review (TRR)

The TRR is a formal review of the contractor's readiness to begin Computer System Configuration Item (CSCI) testing. A Government witness will observe the system demonstration to verify that the system is ready to proceed with CSCI testing. It is conducted after the software test procedures are available and Computer Software Components testing is complete. The purpose of the TRR is for the PMO to determine whether the contractor is, in fact, ready to begin CSCI testing.

8.3.4.7 Functional Configuration Audit (FCA)

The FCA is a formal review to verify that the configuration item's actual performance complied with its development specification. The "B" Specification are derived from the system requirements and baseline documentation. During the FCA, all relevant test data is reviewed to verify that the item has performed as required by its functional and/or allocated configuration identification. The audit is conducted on that item which is representative (prototype or production) of the configuration to be released for production. The audit consists of a review of the contractor's test procedures and results. Information provided will be used by the FCA to determine the status of planned tests.

8.3.3.8 Physical Configuration Audit (PCA)

The PCA is a formal review which establishes the product baseline as reflected in an early production configuration item. It is the examination of the as-built version of both hardware and software configuration items against its technical documentation . The PCA also determines that the acceptance testing requirements prescribed by the documentation are adequate for acceptance of production units of a CI by quality assurance activities. It includes a detailed audit of engineering drawings, final Part II product specifications, technical data, and plans for testing that will be utilized during production. The PCA is performed on all first articles and on the first CIs delivered by a new contractor.

8.3.3.9 Formal Qualification Review (FQR)

The FQR is a systems level configuration audit that is conducted after IOC and to support the Milestone IV decision. The objective is to verify that the actual performance of the CI as determined, through test, complies with its Type "B" Specifications and to document the results of the qualification tests. The FQR and FCA are often performed at the same time; however, if sufficient test results are not available at the FCA to ensure the CI will perform in its operational environment, the FQR can be scheduled.

8.3.3.10 Production Readiness Review (PRR)

The PRR is an assessment of the contractor's ability to produce the items on the contract. It is usually a series of reviews conducted prior to an LRIP or full-scale production decision. For more information, see chapter 15, paragraph 15.3

8.3.3.11 Configuration Change Control

The Configuration Change Control review is an assessment of the impact of engineering or design changes. It is conducted by the engineering configuration control, T&E, and PM portions of the PMO. Every engineering change proposal will require additional testing, and the TEMP must reflect the new schedules and resource requirements. Adequate testing must be accomplished to ensure integration and compatibility of these changes. For example, an engineering change review was conducted to integrate color monitors into the Airborne Warning and Control System (AWACS) to replace the black and white monitors. Further, the AWACS operating software had to be upgraded to handle color enhancement. The review was conducted on the Government Program Management Office (PMO) and then sections of the PMO were tasked to contract, test, engineer, logistically support, control, cost, and finance the change to completion. Configuration control and engineering changes are discussed in MIL-STD-481A.

8.4 SUMMARY

Design reviews are an integral and essential part of the system engineering process. The meetings range from very formal reviews by the Government and contractor Program Managers to informal technical reviews concerned with product or task elements of the work breakdown structure. All reviews share the common objective of determining the technical adequacy of the existing design to meet technical requirements. The DT/OT assessments and test results are made available to the reviews, and it is important that the test community be involved in the completion of all the open action items.

MODULE III

OPERATIONAL / USER TESTING

Operational Test and Evaluation (OT&E) is conducted to ensure that a weapon system meets the validated requirements of the user in a realistic scenario. Operational tests are focused on operational requirements, effectiveness and suitability, and not the proof of engineering specifications, as is the case with development testing. This module provides an overview of OT&E and discusses how OT&E results provide essential information for milestone decisions.

CHAPTER 9

INTRODUCTION TO OPERATIONAL TEST AND EVALUATION

9.1 INTRODUCTION

This chapter provides an introduction to the concept of operational test and evaluation (OT&E). It outlines the purpose of OT&E, discusses the primary participants in the OT&E process, describes several types of OT&E, and includes some general guidelines for the successful planning, execution, and reporting of OT&E programs.

9.2 PURPOSE OF OT&E

Operational test and evaluation is conducted for major programs by an organization that is independent of the developing, procuring, and using commands. It is normally conducted in phases, each of which are keyed to a decision review in the materiel acquisition process. It is conducted with typical user operators, crews, or units in realistic and operational environments. The OT&E provides the decision authority with an estimate of:

(1) The military utility, operational effectiveness and suitability of the new system;
(2) The system's desirability, considering systems already available, and the operational benefits or burdens associated with the new system;
(3) The need for modifications to the new system;
(4) The adequacy of doctrine, organizations, operating techniques, tactics, and training for employment of the system; the adequacy of maintenance support for the system; and the adequacy of the system's performance in the countermeasures environment.

9.3 TEST PARTICIPANTS

OT&E of major systems is managed by an independent testing agency which each military Service is required to maintain. It is accomplished under conditions as operationally realistic as possible. Personnel operating, maintaining, and supporting the system during OT&E are trained to a level commensurate with that of personnel who will actually perform these functions under peacetime and wartime conditions. Program management office personnel and test coordinating groups also play important parts in the overall OT&E process.

9.3.1 Program Management Office

Even though operational testing is performed by an independent organization, the Program Manager (PM) plays an important role in its planning, reporting, and funding. He must coordinate program activities with the test community, especially the Operational Test Agencies. He also helps ensure that testing addresses the critical issues and provides feedback from testing activities to contractors.

At each milestone review, the Program Manager is required to brief the decision authority on the testing planned and completed on the program. It is, therefore, important that the Program Management Office (PMO) personnel have a good understanding of the test program objectives and that they work with the operational test community to ensure that the OT&E is well planned and adequate resources are available. The PMO should involve the test community by organizing Test Coordinating Groups at the program initiation and establishing channels of communication between the PMO and the key test organizations. The PMO can often avoid misunderstandings by aggressively monitoring the system testing and providing up-to-date information to key personnel in OSD and the Services. The PMO staff should keep appropriate members of the test community well informed concerning system problems and the actions undertaken by the PMO to correct them.

9.3.2 Test Coordinating Groups

The Army's Test Integration Working Group (TIWG), Navy's T&E Coordinating Group (TECG), and Air Force's Test Planning Working Group (TPWG) are chartered by their respective Service to coordinate and integrate the planning and execution of the T&E program. The Army and Air Force groups are chaired by a representative of the Program Management Office, often the Program Manager. The Navy's T&ECG is chaired by the development coordinator. The members of these groups represent the user, development and operational testing, independent evaluation, logistics, training, and contractor communities, as appropiate. The functions of the groups are to: facilitate the use of testing expertise, instrumentation, facilities, simulations, and models; integrate test requirements; accelerate the TEMP coordination process; resolve cost and scheduling problems; and provide a forum to ensure that test and evaluation of the system is coordinated. The existence of a test coordinating group does not alter the responsibilities of any command or headquarters and, in the event of disagreement within a group, the issue is resolved through the normal command/staff channels. Within the Air Force, the TPWG may help to prepare the test portions of the request for proposal and related contractual documentation, and evaluate the contractors' proposals. In all of the Services, the groups help develop the TEMP.

9.3.3 Service Operational Test Agencies

The operational test and evaluation organizations should become involved early in the system's life cycle, usually at program initiation, where they can begin to develop strategies for the actual conduct of the operational and evaluation tests. As test planning continues, a detailed TEMP is developed and the test resources are identified and scheduled. During the early stages, the OTAs structure an OT&E program, consistent with the approved acquisition strategy, for the system, identifies critical operational test issues, and assess the adequacy of candidate systems. As the program moves into advanced planning, OT&E efforts are directed toward becoming familiar with the system, encouraging interface between the user and developer and further refining the critical operational issues. Each Service has an independent organization dedicated to planning, executing, and reporting the results of that Service's operational test and evaluation activities. These organizations include the: Army Operational Test and Evaluation Agency (OTEA), Navy Operational Test and Evaluation Force (OPTEVFOR), Air Force Operational Test and Evaluation Center (AFOTEC), and Marine Corps Operational Test and Evaluation Activity (MCOTEA). These organizations are discussed further in Chapter 22.

9.3.4 Test Personnel

Operational testing is conducted on materiel systems with typical user players in as realistic an operational environment as possible. It uses personnel with the same military occupational specialties as those who will operate, maintain, and support the system when it is fielded. Participating troops are trained in the systems operation based on the Service's operational mode summary and mission profiles. Because some operational tests consist of force-on-force tests, the forces opposing the tested system must also be trained in threat tactics and doctrine. For operational testing conducted before full-rate production, most of the training on the system is conducted by the system's contractor. Usually, the contractor trains the school cadre, and those cadre train the other troops. As the system enters full-rate production, the Service assume training responsibilities.

9.4 TYPES OF OT&E

Operational Test and Evaluation can be subdivided into two phases: Operational testing performed before the full-rate production/deployment decision (Pre-production OT&E) and the operational testing performed after the production decision. The Pre-production OT&E includes Operational Assessments, Initial Operational Test and Evaluation (IOT&E) and Follow-On Operational Test and Evaluation (FOT&E). The operational assessments begin very early in the program, frequently after program initiation, and continue until the system is certified ready for the independent operational test and evaluation. The independent operational test and evaluation is conducted just prior to the full-rate production deployment decision and continues until Initial Operating Capability (IOC) is achieved. After the full-rate production/deployment all subsequent operational testing is referred to as Follow-On Operational Test and Evaluation (FOT&E). In the Air Force, if no research and development funding is committed to a system, Qualification Operational Test and Evaluation may be performed in lieu of IOT&E. The Navy uses the term "OPEVAL" to define the operational evaluation to predict the operational effectiveness and operational suitability and the production readiness of a system.

9.4.1 Early Operational Test and Evaluation

Early Operational Test and Evaluation is conducted primarily to forecast and evaluate the operational effectiveness and suitability of the weapon system during development. Operational assessments are conducted on the developing system until the development agency certifies the prototype is ready for Initial Operational Test and Evaluation.

9.4.1.1 Operational Assessments

Operational Assessments begin after program initiation when the Operational Test Agencies (OTAs) start their estimates of operational effectiveness and suitability. The OTA uses any testing results and data from other sources during an evaluation. These data are evaluated by the OTA from an operational point of view. As the program matures, these operational assessments are conducted on prototypes and preproduction articles until the system is fully developed and certified ready for its Initial Operational Test and Evaluation (IOT&E) or OPEVAL in the Navy.

9.4.1.2 Initial Operational Test and Evaluation (or OPEVAL)

Initial Operational Test and Evaluation is the final dedicated phase of OT&E preceding a full-rate production decision. IOT&E is the one of the final examinations that entails dedicated operational testing of production-representative test articles using typical operational personnel in as realistic a scenario as possible. IOT&E is conducted by an operational test and evaluation agency independent of the contractor, Program Management Office, or Developing Agency. DOD Directive 5000.3 defines the test conditions under which such testing must be conducted:

> Operational testing shall be accomplished in an environment as operationally realistic as possible, including threat representative hostile forces. Typical users should operate and maintain the system under conditions simulating combat stress and peacetime conditions.

Further, IOT&E must be conducted without system contractor personnel participation as set forth in Public Law 99-661 by Congress. The results from this test are evaluated and presented to the decision authority prior to the decision to enter full-rate production and to support the beyond-LRIP decision. This phase of OT&E addresses the critical issues identified in the Decision Coordinating Paper (DCP) and the TEMP.

9.4.2 Follow-On Operational Test and Evaluation

Follow-On Operational Test and Evaluation (FOT&E) is conducted after the Milestone III decision. The tests are conducted in a realistic tactical environment similar to that used in OT&E, but a greater number of test items may be used. Normally FOT&E is conducted using production systems. Specific objectives of FOT&E include the testing of modifications that are to be incorporated into production systems, the completion of any deferred or incomplete IOT&E, and assessment of operational availability (Ao), to include spares support. The tests are also used to test the system in a different platform application, new tactical applications, or against new threats.

9.4.3 Qualification Operational Test and Evaluation

Qualification Operational Test and Evaluation (QOT&E) may be performed by the major command, user, or operational test and evaluation agency and is conducted on minor modifications or new applications of existing equipment when no research and development funding is required. An example of a program in which QOT&E was performed by the Air Force is the A-10 Air-to-Air Self Defense Program where the mission of the A-10 was expanded from strictly ground support to include an air-to-air defense role. To accomplish this the A-10 aircraft was modified with off-the-shelf AIM-9, air-to-air missiles, and QOT&E was performed on the system to evaluate its operational effectiveness and suitability.

9.5 TEST PLANNING

Operational test planning is one of the most important parts of the OT&E process. Proper planning facilitates the acquisition of data to support the determination of the weapon system's operational effectiveness and suitability. Planning must be pursued in a "deliberate, comprehensive and structured manner. Careful and complete planning may not guarantee a successful test program, but inadequate planning can result in significant test problems, system failure, and cost overruns.
Operational test planning is conducted by the OTA after program initiation prior to each operational test phase.

Operational planning can be divided into three phases: earlyplanning, advanced planning and detailed planning. Early planning entails critical operational issue development, determining the concept of operation, envisioning the operational environment, and developing mission scenarios and resource requirements. Advanced planning encompasses the determination of the purpose and scope of testing, identification of critical issues, development of test objectives, establishment of a test approach and estimating test resource requirements. Detailed planning involves the development of step-by-step procedures to be followed as well as the coordination of resource requirements necessary to carry out OT&E.

9.5.1 Critical Operational Testing Issues

One of the purposes of OT&E is to resolve critical operational issues about the system. The first step in an OT&E program is to identify these critical issues, some of which are implicit in the definition of OT&E. For example, "How well does the system perform a particular aspect of its mission?" and "Can the system be supported logistically in the field?" Other issues arise from questions being asked about the system's performance or how it will affect other systems with which it must operate. Critical issues provide focus and direction for the operational test and are normally expressed in the form of questions. Identifying the issues is analogous to the first step in the system's engineering process; that is, defining the problem. When critical issues are properly addressed, deficiencies in the system can be uncovered and corrected. They form the basis for a structured technique of analysis by which detailed subobjectives or measures of effectiveness (MOE) can be established. During the operational test, each subobjective is addressed by an actual test measurement. After these issues are identified, the evaluation plans and test design are developed for test execution.

9.5.2 Test Realism

Realism in an OT&E program includes all of the characteristics that make the test look, sound, feel, taste, and smell like actual combat operations. In order to achieve realism in an OT&E, there must be a concern for realism throughout the planning and conduct of the test. The three basic areas of particular significance in applying detailed considerations of realism identified by Roger Smith in his book, "Operational Test and Evaluation: A Systems Engineering Approach", are:

(1) During development of the test concept paper and design of the over all aspects of the test program, the developers must ensure the basic test philosophy is determined and realism is closely woven into this design.
(2) During planning and design of the actual test and development of scenarios, the planners must ensure that realism is included into the operational and maintenance activities.

(3) During the actual conduct of the tests, the field testers must ensure that the tactical realism is maintained.

9.5.3 Selection of a Test Concept

An important step in the development of an OT&E concept is to define the overall test program concept. It must be determined if OT&E will be conducted in parallel with systems development, if all testing is to be done on production equipment, if testing will be evolutionary, and if testing will have to wait until all system capabilities are developed. These questions can best be answered by considering a number of systems aspects such as test information requirements, system availability during test periods, and the implementation of system capabilities. The test concept is driven by the acquisition strategy and is a road map used for test design (para 5.5.3) and evaluation.

9.6 TEST EXECUTION

An operational test plan is only as good as the execution of that plan. The execution is the essential bridge between test planning and test reporting. The test is executed through the OT&E test director's efforts and the actions of the test team. For successful execution of the OT&E plan, the test director must direct and control the test resources and collect the data required for the evaluator to present to the decision authority. He must prepare for testing, activate and train the test team, develop test procedures and operating instructions, control data management, create OT&E plan revisions, and manage each of the test missions. His data management duties will encompass raw data collection, creating a data status matrix, ensuring data quality assurance, processing and reduction, verification, filing, storage, retrieval, and analysis. Once all the tests have been completed and the data is reduced and analyzed, the results must be reported. A sample test organization, the Army organizational framework for OT&E of the I 81mm Mortar, is illustrated in Figure 9-1. (In the Army, the Deputy Test Director from the OTA actually controls the operational test activity.)

9.7 TEST REPORTING

The OT&E test report is a very important document. It must communicate the results of completed tests to decision authorities in a timely, factual, concise, comprehensive and accurate manner. The report must present a balanced view of the weapon system's successes and failures during testing, and illuminate the positive aspects and the system's deficiencies discovered.

There are four types of reports most frequently used in reporting OT&E results. These include status, interim, quick-look, and final reports. The status report gives periodic updates (e.g., monthly, quarterly) and

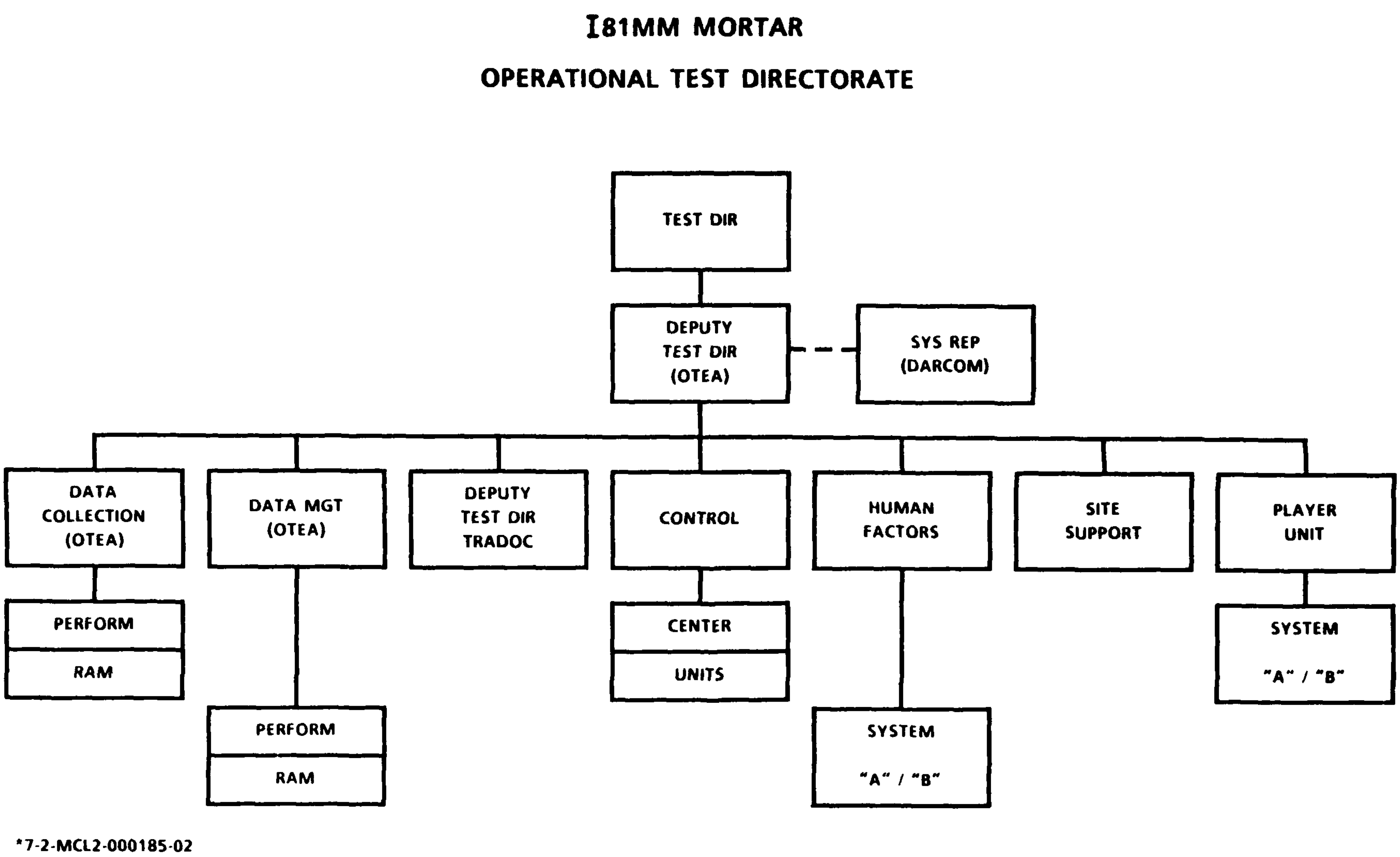


Figure 9-1. Organizational Breakdown of the I81mm Mortar Operational Test Directorate

reports recent test findings (discreet events such as missile firings). The interim report provides a summary of the cumulative test results to date. The quick-look report provides preliminary test results, are usually prepared immediately after a test event (less than 7 days) and may be used to support program decision milestones due to the need to support a decision before the final report can be written. The final test report (Air Force, Navy), or Army evaluation report presents the final test results, conclusions, and recommendations covering the entire OT&E program with all supporting data.

9.8 SUMMARY

The purpose of operational test and evaluation is to assess operational effectiveness and suitability at each stage in the acquisition process. Operational effectiveness is a measure of the contribution of the system to mission accomplishment under actual conditions of employment. Operational suitability is a measure of the maintainability and reliability of the system, the effort and level of training required to maintain, support, and operate it, and any unique logistic or training requirements it may have. OT&E may also provide information on tactics, doctrine, organization, and personnel requirements and may be used to assist in the preparation of operating and maintenance instructions and other publications. Its most important aspect is that it provides an independent evaluation of the utility of the system and the feasibility of employing it.

CHAPTER 10

OT&E TO SUPPORT MILESTONE DECISIONS

10.1 INTRODUCTION

Operational test and evaluation is conducted in keeping with principles of objectivity and an impartial evaluation to provide to the decision authority, prior to each major milestone review, the operational information necessary to resolve critical operational issues. The principles of testing are summarized in three terms--adequacy, quality, and credibility:

Adequacy--The amount of data and realism of test conditions must be sufficient to support the resolution of the critical issues.

Quality--The test planning, control of test events, and treatment of data must make the operational information clear and accurate.

Credibility--The conduct of the test and data handling must be separated from external influence and personal self-interest.

This chapter discusses the operational testing conducted to provide information to support DOD executive level management decisions on major acquisition programs. Figure 10-1 illustrates how T&E relates to the acquisition process.

10.2 OT&E DURING THE CONCEPT EXPLORATION/DEFINITION PHASE (Milestone 0 to Milestone I)

Operational Test and Evaluation (OT&E) is accomplished using a test cycle of successive actions and documents. During the early stages of the program, the process is informal and modified as necessary. As programs mature, documentation for major systems and those designated by DOT&E for oversight must be sent to OSD for approval before the testing can be conducted or the systems can be cleared to proceed into low-rate initial production. OT&E conducted during the Concept Exploration/Definition (CED) Phase, operational assessment, is focused on investigating the deficiencies identified during the mission area analysis. Operational testers participate in these evaluations to validate the OT&E requirements for future testing and to identify those issues and criteria which can only be resolved through OT&E in order to initiate early test resource planning.

The OT&E objectives prior to Milestone I are to assist in selecting alternatives to resolve the mission area deficiencies, and to assess the operational impact of the system. This early assessment also

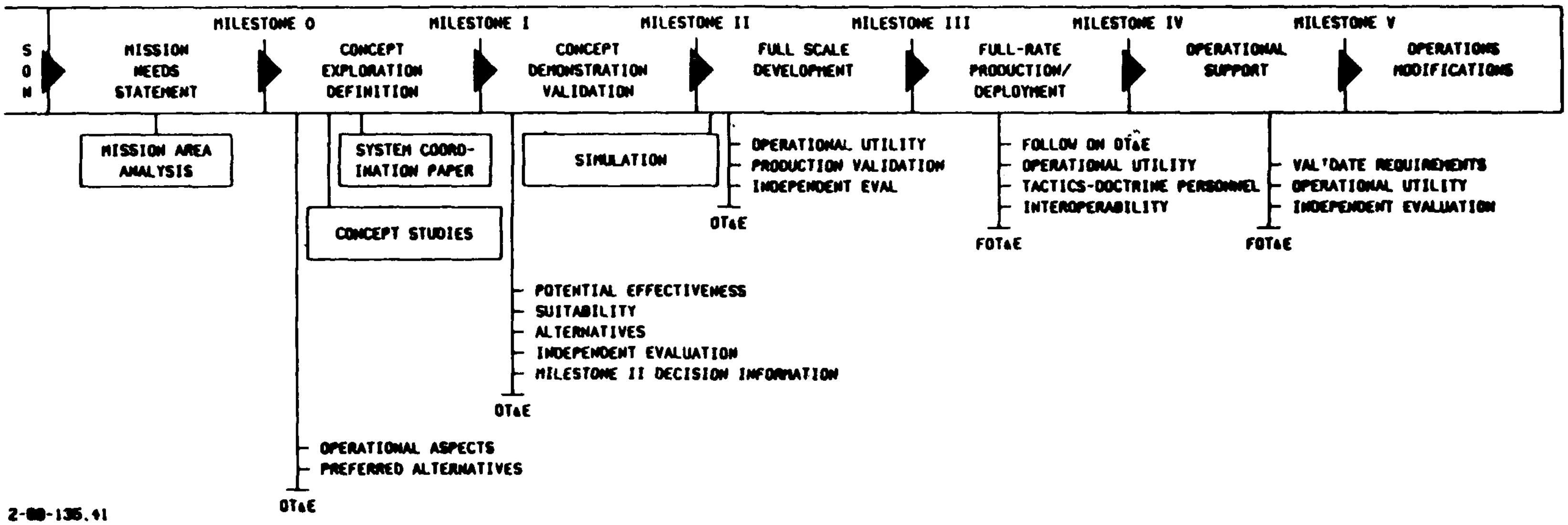


Figure 10-1. OT&E Related to the Milestone Process

provides data to support a decision on whether or not to enter the Concept Demonstration/Validation phase. OT&E conducted during the CED phase supports the development of estimates of:

(1) The military need for the proposed system;
(2) A demonstration that there is a sound physical basis for a new system;
(3) An analysis of the concept, based on demonstrated physical phenomena, for satisfying the military need;
(4) The system's affordability and life-cycle cost;
(5) The ability of a modification to an existing U.S. or Allied system to provide needed capability;
(6) An operational utility assessment; and
(7) An impact of the system on the force structure.

At Milestone I, there is normally no hardware available for the operational tester. Therefore, the early operational assessment is conducted from: surrogate force development test and experiment data, breadboard models, factory user trials, mock-up/simulators, and user demonstrations. This makes the early assessments difficult and some areas cannot be covered in-depth; however, these assessments provide vital introductory information on the systems potential operational utility.

The OT&E products from this phase of testing include the information provided to the decision authority, data collected for further evaluation and the input to the Decision Coordinating Paper (DCP), Test and Evaluation Master Plan (TEMP), and early test and evaluation plans. Special logistics problems, program objectives, program plans, performance parameters, areas of major risk, system alternatives, and acquisition strategy are areas of primary concern to the operational tester during this phase and must be carefully evaluated in order to project the system operational capabilities.

10.3 OT&E DURING THE CONCEPT DEMONSTRATION/VALIDATION PHASE (Milestone I to Milestone II)

OT&E during the Concept Demonstration/Validation Phase, is conducted to support the Milestone II (MS-II) decision regarding a system's readiness to move into Full-Scale Development. In all cases, appropriate and adequate T&E must be conducted prior to the MS-II decision, thereby reducing risk and uncertainty before more resources are committed. As appropriate, Low-Rate Initial Production (LRIP) of selected components and quantities may be approved at MS-II to verify production capability and to provide test resources needed to conduct interoperability, live fire, or operational testing.

10.3.1 Objectives of Early Operational Asessments

Early operational assessment efforts are conducted to identify the best approach, indicate the risks and solutions for this phase of the development, examine operational aspects of the systems development, and estimate potential operational effectiveness and suitability. Additionally, an analysis of the planning for transition from development to production is initiated. The Operational Assessments to support the MS-II decision are intended to:

(1) Assess the potential of the new system in relation to existing capabilities.
(2) Assess system effectiveness and suitability so that affordability can be evaluated in terms of program cost versus the military value.
(3) Assess the adequacy of the concept for employment, supportability and organization; doctrinal, tactical, and training requirements; and related critical issues.
(4) Estimate the need for the selected systems in consideration of the threat and system alternatives based on military utility.
(5) Assess the validity of the operational concept.
(6) List the key risk areas and critical operational issues that need to be resolved before Full-Scale Development is initiated.
(7) Assess the need for Low-Rate Initial Production of hardware to support testing prior to the full-rate production decision.

The OT&E during this phase may be conducted on brassboard configurations, experimental prototypes, or advanced development prototypes. There may also be an advanced prototype system available for the operational tester. However, the OT&E assessments may also make use of many other additional data sources. Examples of additional sources often used by the Army during this phase include: Concept Evaluation Program Tests, Innovative Testing, Force Development Tests or Experimentations (FDT&E), Source Selection Tests, User Participation in DT&E, and Operational Feasibility Tests. The results from this testing, analysis, and evaluation are documented in the DCP. This document along with the mission needs documentation and Test and Evaluation Master Plan assist in the review process for the MS-II decision.

10.3.2 OT-I of the Advanced Attack Helicopter

The Army's testing of the Advanced Attack Helicopter (AAH) provides an example of operational testing conducted during the Demonstration/Validation Phase:

> In this program, DT-I and OT-I activities were integrated wherever possible. The OT-I compared the two candidate systems, (YAH-63 and YAH-64) with their respective baseline (each an AH-1S) under limited

operational conditions to examine the following aspects relative to mission performance: reliability, availability, and maintainability characteristics; combat survivability; and human factors data. The tests were conducted by DT&E pilots at Edwards Air Force Base and China Lake Naval Weapons Center, California. The aircraft were tested in the airframe-only configuration (i.e., *without* weapons and target acquisition subsystems), for 16 hours per airframe. Within this limited time, sample operational events included: hover-out-of-ground-effect, low-level flight, contour flying, nap-of-the-earth flight, and simulated firing missions to test detectability. Test results supported the conclusion, "that the generic AAH performed as well as, or better than, the baseline AH-1S and was judged suitable to continuation to the next phase in the acquisition cycle."

10.4 OT&E DURING THE FULL-SCALE DEVELOPMENT PHASE (Milestone II to Milestone III)

The OT&E during the Full-Scale Development phase is conducted on production representative systems. These operational tests estimate the actual operational effectiveness and suitability, and ensure that the system meets operational thresholds. Just prior to the Full-Rate Production/Deployment, Milestone III (MS-III) decision, a dedicated test and evaluation is conducted on equipment that has been formally certified by the Program Manager as being ready for the "final OT&E" before the full-rate production/deployment decision. This dedicated OT&E is conducted in as operationally realistic test environment as possible.

10.4.1 OT&E Objectives

The OT&E tests conducted prior to the full-rate production decision are characterized by testing performed using organizational units in controlled field exercises to examine the organization and doctrine, integrated logistics support, threat, communications, command and control, and tactics associated with the operational employment of the unit, under continuous tactical operations. This OT&E is conducted to support the Full-Rate Production Review, MS-III, and includes estimates which:

(1) Assess operational suitability and effectiveness;
(2) Assess the vulnerability/lethality of the system;
(3) Assess the systems reliability, maintainability, and plans for integrated logistics support;
(4) Evaluate manpower, personnel, training and safety requirements.

(5) Validate organizational and employment concepts;
(6) Determine training and logistics requirements deficiencies; and
(7) Assess the system's readiness to enter the Full-Rate Production/ Deployment Phase.

10.4.2 OT-II of the Advanced Attack Helicopter

The AAH OT-II was a comparative, three-phase test conducted at Fort Hunter-Liggett, California. Typical organizations and equipment were used during the test and operational units provided personnel and resources for both the AH-64 and baseline AH1S aircraft sections. The AH1S and AH-64 aircraft were flown in the same operational and threat environment. The three phases of the test included a training phase, non-live fire phase, and live fire phase. Appropriate exploratory trials preceded each phase. Force-on-force and many-on-many engagements, with real time casualty assessments, were conducted during the non-live fire phase. The live-fire phase included the firing of all of the AAH weapons. The purpose of the OT-II was to assess the military effectiveness of the AH-64 against the baseline aircraft. The AH-64 was also evaluated in terms of RAM, and supportability in the operational environment. The report of the OT-II stated: "the performance of the AH-64 was adequate for combat, superior to the present attack helicopters, night capable, and survivable." There were no operational issues which were considered to preclude the acquisition and development of the system.

10.5 OT&E DURING THE FULL-RATE PRODUCTION/DEPLOYMENT PHASE (Milestone III to Milestone IV)

If a program is large and there is a significant time between the beginning of low-rate initial production and full-rate production, there may be a need to conduct a Service-base Program Review or OT-III before a decision to proceed into full-rate production can be made.

After the MS-III decision, the emphasis shifts towards procurement of production quantities, repairing hardware deficiencies, managing changes, and phasing in full logistics support. During initial deployment of the system, the OT&E agency and/or the user may perform Follow-On Test & Evaluation (FOT&E) to refine the effectiveness and suitability estimates made during earlier OT&E.

The FOT&E is performed on production articles, by an operational command; it is normally funded with operational and maintenance funds. The FOT&E conducted during this phase may also be used to:

(1) Ensure that the production system performs as well as reported at the MS-III review;
(2) Demonstrate expected performance and reliability improvements; and
(3) Assure that the correction of deficiencies identified during earlier testing have been completed.

10.5.1 Objectives of Production OT&E

The primary objectives of OT&E conducted after the full-rate production decision are to refine the estimates of operational effectiveness and suitability, to identify remaining operational deficiencies, to clear any conditional deficiencies noted at the Full-Rate Production Review, to evaluate systems changes, or to evaluate the system against changing operational needs. The test is also conducted for block revisions to a system's software to verify sustained software improvements.

10.6 OT&E DURING THE LOGISTICS READINESS AND SUPPORT PHASE (Milestone IV to Milestone V)

Testing conducted after the Milestone IV decision will encompass a review 1 to 2 years after initial operational deployment of the system. Operational testing is conducted to assure that operational readiness and support objectives are being achieved and maintained during the first several years of the system's life. The testing is also conducted on production equipment that includes all modifications, product improvements and block upgrades to determine operational readiness and supportability.

10.6.1 FOT&E After the Full-Rate Production Decision

OT&E can also be the follow-on operational test and evaluation that is conducted on systems that go into Full-Rate Production and have not been through an independent (Initial) OT&E. The objectives of OT&E in this case, are to validate the operational effectiveness and suitability of the production system or to perform an operational assessment of the system in new environments, in different platform applications, in new tactical applications, or against new threats.

10.6.2 OT&E Objectives

The testing objectives to support the Logistics Readiness and Support Phase Review are:

(1) Assess the logistics readiness and sustainability;
(2) Evaluate the weapon support objectives;
(3) Assess the implementation of integrated logistics support plans;
(4) Evaluate the capability of the logistics support activities;
(5) Determine the disposition of displaced equipment; and
(6) Evaluate the affordability and life-cycle of the system.

10.7 OT&E SUPPORT OF OPERATION SUPPORT (Milestone IV to Milestone V)

After the Milestone IV review, operational testing consists of additional FOT&E as required to refine the effectiveness and suitability estimates and to confirm that deficiencies noted during previous tests have been corrected. The Milestone V review is conducted 5 to 10 years after initial deployment of the system to determine if major upgrades are necessary, or if existing deficiencies warrant development of a replacement system.

OT&E conducted to support the Milestone V review is conducted on selected product improvements, systems modifications, against new threats, or whenever deemed necessary to determine the systems effectiveness and suitability in relation to its tactical employment environment. The objectives of the FOT&E during the Operational and Support Phase are to determine:

(1) If the system can continue to meet its original or evolved mission requirement;
(2) The need for modifications or upgrades to ensure that mission requirements will be met;
(3) If the system is capable to meet changes in threat that require increased capability or utility;
(4) If changes in technology have occurred that present an opportunity for a significant breakthrough in systems worth; and
(5) The disposition of equipment that is being replaced.

10.8 SUMMARY

Operational test and evaluation is that T&E (Operational Assessments or IOT&E) or FOT&E conducted to estimate a system's operational effectiveness and suitability, identify needed modifications, provide information on tactics, doctrine, organizations and personnel requirements, and evaluate the systems logistic supportability. The acquisition program should be structured to allow operational assessment or evaluation to begin early in the development cycle and to continue throughout the system's life cycle.

MODULE IV

SPECIALIZED TESTING

The nature of a weapon system sometimes requires the use of a specially-tailored test and evaluation program. In some cases, hazardous testing must be performed. In other cases, testing must be conducted by specialized organizations or at special times in the development life cycle.

This module addresses the testing of special weapons (such as chemical, laser, and space systems); embedded computer systems; electronic warfare and command and control systems; logistics infrastructure test & evaluation, and production related testing activities.

CHAPTER 11

TESTING THE SPECIAL CASES

11.1 INTRODUCTION

This chapter covers the special factors and alternative test strategies that the tester must consider in testing dangerous or lethal weapons, systems that involve one-of-a-kind or limited production, and systems with high cost and/or special security considerations. Examples include chemical and laser weapons, ships, space weapons, missile systems, and electronic warfare (EW), command and control (C^2), and intelligence systems.

11.2 TESTING OF HAZARDOUS WEAPONS

The tester of dangerous or lethal systems, such as chemical and laser weapons, must consider various safety, health, and medical factors in developing his test plans, such as:

(1) Provision of medical facilities for pre- and post-test checkups and emergency treatment;
(2) Need for protective gear for participating/observer personnel;
(3) Approval of the test plan by Surgeon General;
(4) Restrictions in selection of test participants (e.g., medical criteria or use of only volunteer troops); and
(5) Restricted test locations.
(6) Environmental Impact Statements

Additionally he must allow for additional planning time, test funds and test resources to accommodate such factors.

11.2.1 Chemical Weapons Testing

The testing of chemical weapons poses unique problems because the tester cannot perform actual open air field testing with real nerve agents or other toxic chemicals. Since the United States signed and ratified the Geneva Protocol of 1925, U.S. policy has been that the United States will never be the first to use lethal chemical weapons; it may, however, retaliate with chemical weapons if so attacked. In addition to the health and safety factors discussed in the last paragraph, the test issues that the chemical weapons tester must address include:

(1) All possible chemical reactions due to variations such

as moisture, temperature, pressure, and contamination;

(2) Physical behavior of the chemical, i.e., droplet size, dispersion density, and ground contamination pattern, when used operationally;

(3) Toxicity of the chemical, i.e., lethality and duration of contamination, when used operationally; and

(4) Safety of the chemical weapon during storage, handling, and delivery.

(5) Decontamination Process

Addressing all of these issues requires a combination of laboratory toxic chamber tests and open air field testing. The latter must be performed using "simulants", which are substances that replicate the physical and chemical properties of the agent, but with no toxicity.

The development and use of simulants for testing is an area which will require increased attention as more chemical weapons are developed. Chemical agents can demonstrate a wide variety of effects depending on such factors as moisture, temperature, and contamination. Consequently, the simulants must be able to replicate all possible agent reactions; it is likely that several simulants would have to be used in a test to produce all predicted agent behaviors. In developing and selecting simulants, the tester must thoroughly understand all of the chemical and physical properties and possible reactions of the agent as possible.

Studies of the anticipated reactions can be performed in toxic chamber tests using the real agent. Here, such factors as changes in moisture, temperature, pressure, and levels of impurity can be controlled to assess the agent's behavior. But, the tester must think through all possible environmental conditions in which the weapon could operate, so that all cases can be tested in the laboratory chamber with the real agent. For example, during development testing of the BIGEYE chemical weapon, it was found that higher than expected temperatures due to aerodynamic heating caused pressure buildup in the bomb body that resulted in the bomb exploding. This caused the operational concept for the BIGEYE to be changed from onboard mixing of the two chemicals to mixing after release of the bomb.

Tests to confirm toxicity must be conducted in the actual environment using simulants. Since the agent's toxicity is dependent on such factors as droplet size, dispersion density, ground contamination pattern, and degradation rate, a simulant that behaves like the agent must be used in actual field testing. Agent toxicity is determined in the lab.

The Services publish a variety of technical documents on specific chemical test procedures. Documents such as the U.S. Army Test and Evaluation Command (TECOM) Pamphlet 310-4, which is a bibliography that includes numerous reports on chemical testing issues and procedures, can be consulted for specific documentation on chemical testing.

11.2.2 Laser Weapons Testing

Many new weapon systems are being designed with embedded laser rangefinders and laser designators. Because of the danger to the human eye posed by lasers, the tester must adhere to special safety requirements and utilize special locations during T&E. For instance, the only Army installation in the continental United States permitting free play airborne laser testing is Ft. Hunter-Liggett; during tests involving lasers, the airspace must be restricted and guards must be posted to prevent anyone from accidently venturing into the area. A potential solution to the safety issue is to develop and use an "eye-safe" laser for testing. The tester must ensure that eye-safe lasers produce the same laser energy as the real laser system.

Another concern of the laser energy weapons tester is the accurate determination of laser energy level and location on the target. Measurements of the laser energy on the target are usually conducted in the laboratory as part of DT. In the field, video cameras are often used to verify that the laser designator did indeed illuminate the target. Such determinations are important when the tester is trying to attribute weapon performance to behavior of the laser, behavior of the guidance system, or some other factor.

TECOM Pamphlet 310-4, a bibliography of Army test procedures, lists several documents which cover the special issues associated with laser testing.

11.3 SPACE SYSTEM TESTING

From a historical perspective, space system acquisition has posed several unique problems to the test process (especially the operational test process) which generally fall into four categories; limited quantities/high cost; "block upgrade" approach to acquisition; operating environment (peacetime and wartime); and test environment.

(1) Limited quantities/high cost - Space systems have traditionally involved the acquisition of a relatively few (historically less than 20) systems at extremely "high per unit costs" (in comparison with more traditional military systems). The high per unit costs are driven by a combination of high transportation costs (launch to orbit); high life-cycle reliability requirements and associated costs because of the lack of an "on-orbit" maintenance capability; and the high costs

associated with the "leading edge" technologies that tend to be a part of spacecraft design. From a test perspective, this tends to drive space system acquisition strategy into the "non-standard" approach addressed in paragraph 11.4 below. The problem is compounded by the "block upgrade" approach to acquisition addressed in the next paragraph.

(2) Block upgrade approach to acquisition - Due to the "limited buy" and "high per unit cost" nature of spacecraft acquisition, these systems tend to be procured using a "block upgrade" acquisition strategy. Under this concept, "the decision to deploy" is very often made at the front end of the acquisition cycle and the first prototype to be placed in orbit becomes the first operational asset. As early and follow-on systems undergo both ground and on-orbit testing (either DT&E or OT&E), discrepancies are corrected by "block changes" to the next system in the pipeline. This approach to acquisition can perturb the test process in that the tester may not have any formal milestone decisions to test towards. His focus must change toward being able to influence the design of (and block changes to) systems further downstream in the pipeline. Additionally, the fact that the first "on-orbit" asset usually becomes the first operational asset creates pressure from the operational community to expedite (and sometimes limit) testing so that a limited operational capability can be declared and the system can begin fulfilling mission requirements. Once the asset "goes operational," any use of it for testing will have to compete with operational mission needs - a situation where the tester may find himself in a positon of relatively low priority. Recognition of these realities and careful "early-on" test planning can overcome many of these problems, but the tester needs to be involved and ready much earlier in the cycle than with traditional systems.

(3) Operating environment (peacetime and wartime) - Most currently deployed space systems and near-term future space systems operate in the military support arena such as tactical warning/attack assessment, communications, navigation, weather, and intelligence, and their day-to-day peacetime operating environment is not much different from the wartime operating environment except for activity level (i.e., message throughput, more objects to track/see etc.) Historically space has also been a relatively benign battlefield environment because of technology limitations in the capability of potential adversaries to reach into space with weapons. This combination of support type missions and a battlefield environment that is not much different from the peacetime environment has played a definite role in allowing systems to reach limited operational capability without as much dedicated prototype system level testing as one might see on other type systems. However, this situation is likely to change with the advent of systems such as the Strategic Defense Initiative (SDI) where we will then have large numbers of actual weapons systems sitting passively on alert in space and where day-to-day peacetime operations will not be as much of a mirror image of the anticipated battlefield environment. Likewise, the elevation of the battlefield

into space and the advancing technologies which allow potential adversaries to reach into space may also change the thrust of how space systems need to be tested in space. One might expect to see more of a need for dedicated on-orbit testing on some type of a space range where the battlefield environment can be replicated - a situation similar to the dedicated testing done today on test ranges with Army, Navy, and Air Force weapons.

(4) Test Environment - The location of space assets in "remote" orbits also compounds the test problem. Space systems simply do not have the ready access (as with ground or aircraft systems) to correct deficiencies identified during testing. This situation has driven the main thrust of testing into the "pre-launch" ground simulation environment where discrepancies can be corrected before the system becomes inaccessible. However, as indicated in the previous paragraphs, as space system missions change from a war support focus to a war fighting focus, and, as the number of systems required to do the mission increases out of the "high reliability/limited number" mode into a more traditional "fairly large number buy" mode, then one would expect future space system testing to become more like that associated with current ground, sea, and air systems. From a test perspective, this could also create unique "test technology" requirements in that with these systems we will have to bring the test range to the operating system as opposed to bringing the system to the range. Lastly, because the space environment tends to be "visible to the world" (others can observe our tests as readily as we can), unique test operations security methodologies may be required to allow us to achieve test realism without giving away system vulnerabilities.

In summary, current and near term future space systems have unique test methodologies. However, looking toward the future, where space operations might entail development/deployment of large numbers of weapon platforms on orbit with lower design life reliability (because of cost) and where day-to-day peacetime operations do not mirror the wartime environment, space system testing requirements may begin to more closely parallel those of more traditional weapon systems.

11.4 TESTING WITH LIMITATIONS

Certain types of systems cannot be tested using relatively standard T&E approaches for reasons such as a non-standard acquisition strategy, resource limitations, or cost, safety, or security constraints. The TEMP must contain a statement that identifies "those factors that will preclude a full and completely realistic operational test... (IOT&E and FOT&E)," such as inability to realistically portray the entire threat, limited resources or locations, safety, and system maturity. The impact of these limitations on the test's critical operational issues must also be addressed in the 'P.

Non-standard acquisition strategies are often used for one-of-a-kind or limited production systems. Examples of these include space systems, missiles, ships, electronic warfare (EW), C^3, and intelligence systems. For one-of-a-kind systems, the production decision is often made prior to system design, hence testing does not support the traditional decision process. In limited production systems, there are often no prototypes available for test, so the tester must develop innovative test strategies. DoDD 5000.3 states:

> "for these programs, the principle of DT&E of components, subsystems, and prototype or first production models of the system shall be applied. For these special systems, the Component [Operational Test Agency] OTA shall monitor and participate in relevant laboratory and controlled testing, and use these test results, as appropriate, to provide an assessment of system effectiveness and suitability. Compatibility and interoperability with existing or planned equipment shall be tested during DT&E and OT&E. After production of the system, the Component OTA (or user, with the concurrence of the OTA) shall conduct a rigorous operational test and provide an evaluation, as appropriate, to provide an assessment of system effectiveness and suitability in the same manner as for more typical systems."

11.5 OPERATIONS SECURITY AND T&E

Operations security (OPSEC) issues must be considered in all test planning. DoDD 5000.3 requires the protection of "sensitive design information and test data" throughout the acquisition cycle by,

(1) Protection of sensitive technology...;

(2) Elimination of nonsecure transmittal data on and from test ranges; and

(3) Providing secure communications linking DoD agencies to each other and to their contractors."

Such protection is obviously costly and will require additional planning time, test resources, and test constraints. The test planner must determine all possible ways in which the system could be susceptible to hostile exploitation during testing. For example, announcement of test schedule and location could allow monitoring by unauthorized persons. Knowledge of the locations of systems and instrumentation or test concepts could reveal classified system capabilities or military concepts. Compilations of unclassified data could, as a whole, reveal classified information, as could surveillance (electronic or photographic) of test activities or intercept of unencrypted transmissions. The test and evaluation regulations of each Service require an operational security plan for a test. AFR 55-43 provides a detailed list of questions the test planner can use to identify the potential threat of exploitation.

11.6 SUMMARY

All weapon systems tests are limited to one degree or another, but certain systems face major limitations that could preclude a full and realistic test. The test planners of these special systems must allow additional planning time, budget for extra test resources, and devise alternative test strategies to work around testing limitations caused by such factors as security restrictions, resource availability, environmental safety factors, and non-standard acquisition strategies.

CHAPTER 12

EMBEDDED COMPUTER SYSTEMS TESTING

12.1 INTRODUCTION

Software components present a major development risk for military computer systems. They escalate the cost and reduce the reliability of military systems. Embedded computer systems whose major function is not data processing are physically incorporated into larger systems whose major function is not data processing. The outputs of the systems are normally information, control signals or computer data required by the host system to complete its mission. Although hardware and software contribute in equal measure to successful implementation of embedded computer system functions, there have been relative imbalances in their treatment during system development.

The development of embedded systems involves a series of activities in which there are frequent opportunities for errors. Errors may occur at the inception of the process when the requirements of the system may be erroneously specified or later in development cycle when system specifications are implemented. This chapter will address the use of testing to control the development risk of embedded computer systems, particularly as it pertains to the software development process.

12.2 MISSION CRITICAL COMPUTER RESOURCES

The term Mission Critical Computer Resources (MCCR) is defined as automated data processing equipment, software or services where the function, operation or use of the equipment software or services:

(1) involves intelligence activities;
(2) involves cryptologic activities related to national security;
(3) involves command and control of military forces;
(4) involves equipment that is an integral part of a weapons system; or
(5) is critical to the direct fulfillment of military or intelligence missions.

Acquisition of MCCR is defined by DoD Directive 5000.29, Management of Computer Resources in Major Defense Systems, which requires the validation of computer resource requirements prior to Milestone II, to ensure conformance with stated operational requirements. After Milestone II computer resources life cycle planning must continue to ensure adequate personnel, system integration, quality and integrity.

12.3 PURPOSE OF SOFTWARE TEST AND EVALUATION

A major problem in software development is a lack of well defined requirements. If requirements are not well defined, errors can multiply throughout the development process. As is illustrated in Figure 12-1, errors may occur at the very inception of the process during requirements definition, when objectives may be erroneously or imperfectly specified, during the later design and development stages, when these objectives are implemented; as well as during software maintenance and operational phases when software changes are needed to eliminate errors or enhance performance.

Current estimates of increased software costs arising from incomplete testing help to illustrate the dimension of software life-cycle costs. Averaged over the operational life cycle of a computer system, development costs encompass approximately 30 percent of total system costs. The remaining 70 percent of life-cycle costs are associated with maintenance which includes system enhancements and error correction. More complete testing during earlier development phases may have detected these errors.

The relative costs of error correction increases as a function of time from the start of the development process. Relative costs of error correction rises dramatically between requirements and design phases and then even more dramatically during code implementation (a representative cost function is shown in Figure 12.2).

Previous research in the area of software T&E reveals that half of all maintenance costs are incurred in the correction of previously undetected errors. Approximately one half of the operational life cycle costs can be traced directly to inadequate or incomplete testing activities. In addition to cost increases, operational implications of software errors in weapon systems can result in mission critical software failures which may impact mission success and personnel safety.

A more systematic and rigorous approach to software testing is required. To be effective, this approach must be applied to all phases of the development process in a planned and coordinated manner, beginning at the earliest design stages and proceeding through operational testing of the integrated system. Early detailed software test and evaluation (T&E) planning is critical to the successful development of a computer system.

12.4 SOFTWARE DEVELOPMENT PROCESS

A success oriented software development methodology is characterized by a phased approach starting with a detailed requirements analysis. Key elements of this methodology include a top down software

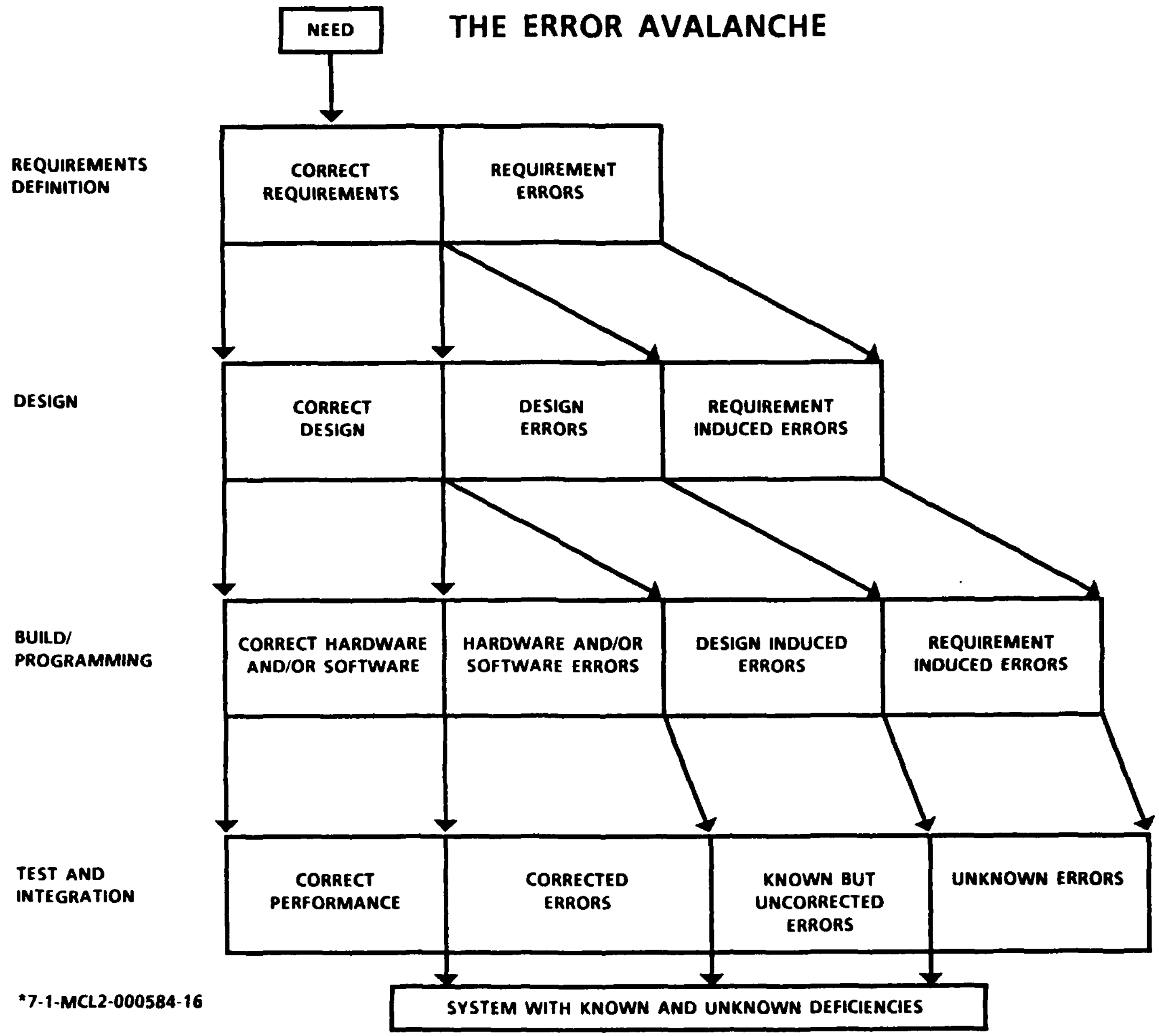


Figure 12-1. The Error Avalanche

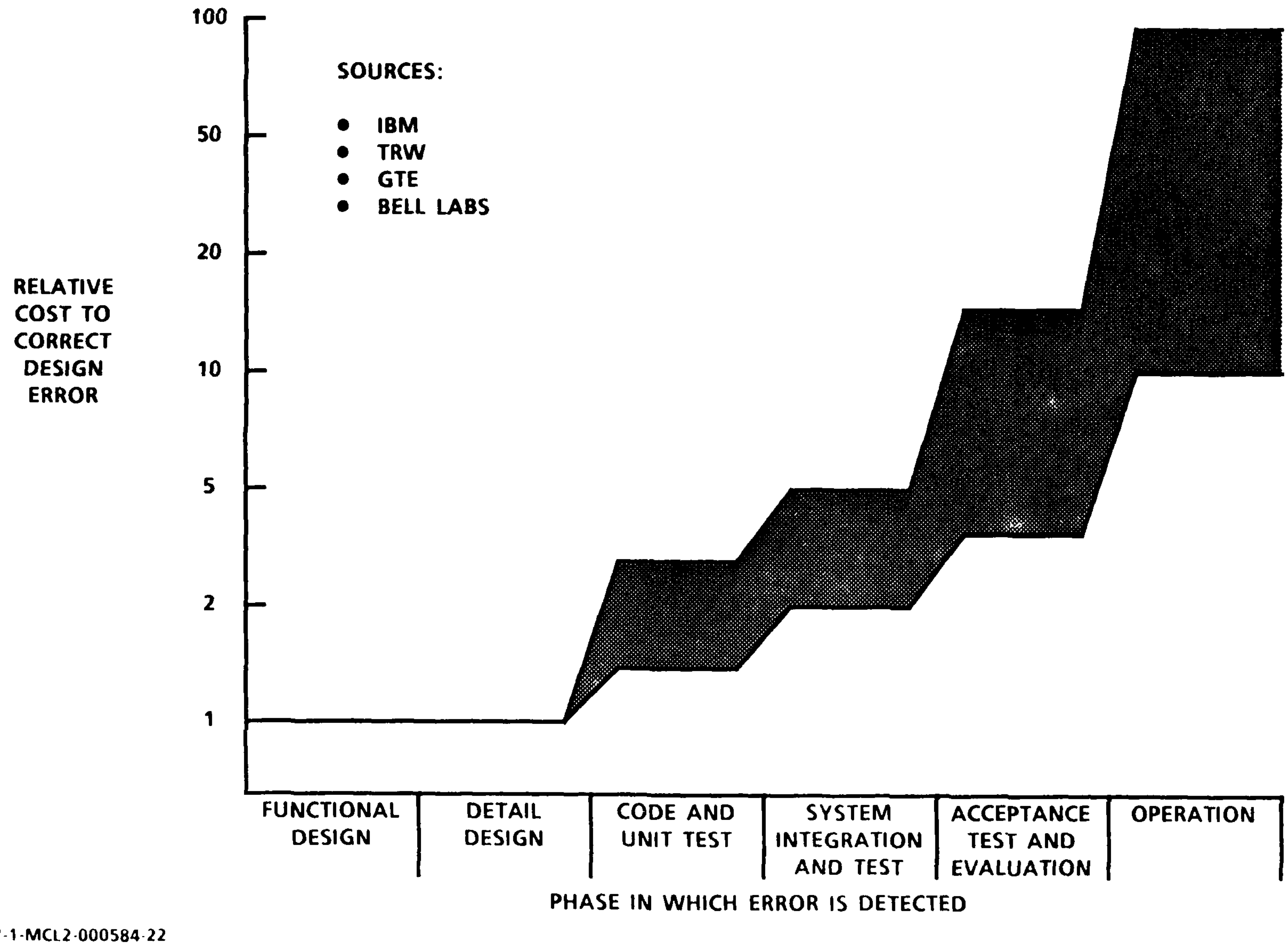


Figure 12-2. Relative Cost of Software Error Corrections

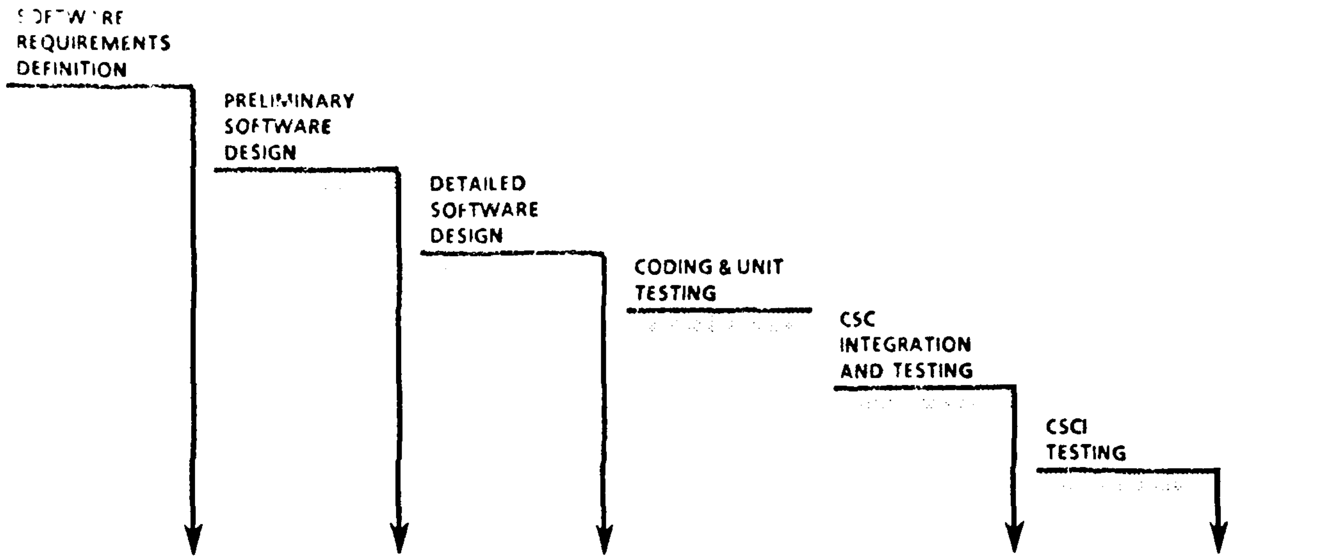
design, early design and configuration management controls, frequent milestone reviews and the continuous use of software documentation as a means of controlling and monitoring the development team and tracking the interdependence of the software modules. DoD Standard 2167A establishes requirements to be applied during development and acquisition of software in Mission Critical Computer Resources Systems. The software development cycle in DoD STD 2167A is divided into six consecutive phases:

(1) Software requirements analysis,
(2) Preliminary software design,
(3) Detailed software design,
(4) Coding and unit testing,
(5) Computer Software Component (CSC) Integration and Testing, and
(6) Computer Software Configuration Item (CSCI) testing.

Each phase is concerned with a specific aspect of the overall software development activity. In general, the phases are separated by milestone reviews. These reviews occur at the end of a particular phase and provide a means of formally monitoring progress. The production of software documentation goes on throughout the phases. Figure 12.3 illustrates the major documentation throughout the development process. This approach, in conjunction with unit development folders (UDFs), assist in maintaining a clearly definable work breakdown structure (WBS) for successfully managing a software development effort. These UDFs contain all relevant material related to each identified software module.

Software engineering technologies used to produce operational software are key risk factors in a development program. The TEMP is should determine which of these technologies increase risk and have a life cycle impact. A principal source of risk is the support software required to develop operational software. In terms of life cycle impact, a common source of operational software problems are associated with the difficulty in maintaining and supporting the software once deployed. Software assessment requires an analysis of the life cycle impact which varies depending on the technology used to design and implement the software. One approach to reducing the long-term life cycle risks is to use common hardware throughout the development and operation of the software. These life cycle characteristics which affect operational capabilities must be addressed in the TEMP and tests should be developed to test problems that these characteristics raise. The technology used to design and implement the software may significantly affect software supportability and maintainability. As an example, High Order Languages (HOL) that have yet undemonstrated application are a frequent source of risk. The first use of an HOL increases the risk in three dimensions:

(1) A "learning curve" effect limits the productivity of software development team in the early phases.



	SOFTWARE REQUIREMENTS REVIEW	PRELIMINARY DESIGN REVIEW	CRITICAL DESIGN REVIEW	TEST READINESS REVIEW	SOFTWARE PRODUCT ACCEPTANCE
SOFTWARE DEVELOPMENT PLAN	C	U	U	U	
SOFTWARE STANDARDS AND PRACTICES MANUAL			C		
SOFTWARE QUALITY PROGRAM PLAN	C	U	U	U	
SOFTWARE CONFIGURATION MANAGEMENT PLAN	C				
END PRODUCT ACCEPTANCE PLAN	C				
SOFTWARE REQUIREMENTS SPECIFICATIONS	C				
SOFTWARE SYSTEM SUB-SYSTEM SPECIFICATIONS	C				
INTERFACE CONTROL DOCUMENT		C			
SOFTWARE PRODUCT SPECIFICATION					C
SOFTWARE TEST PLAN		C			
SOFTWARE TEST DESCRIPTION (CASE)		P	C		
SOFTWARE SYSTEM T&E PLAN & PROCEDURES			P	C	
SOFTWARE MANUALS				C	
SOFTWARE TEST REPORTS				C	
BUILD DESCRIPTION DOCUMENT				P	C

LEGEND
C - COMPLETE
P - PRELIMINARY
A - AS REQUIRED
U - UPDATE

Figure 12-3. Major Software Documentation

'7-2-MCL2 000185-03

(2) The immaturity of the HOL compiler increases the probability that software errors may be introduced during the implementation.
(3) The new HOL may not have demonstrated suitability for the given application.

The TEMP must sufficiently describe the acceptance criteria for the written specifications, operational suitability and effectiveness. The specifications must define the required software characteristics in order to set goals and thresholds for mission critical functions. Additionally, these characteristics should be evaluated at the appropriate stage of system development, rather than at some arbitrarily imposed milestone.

12.5 T&E IN THE SOFTWARE LIFE CYCLE

Software testing is defined as a controlled exercise of program code to expose errors. Software test planning should be described in the TEMP with the same care as test planning for other system components.

12.5.1 TESTING APPROACH

While software is normally developed in a top-down approach, all testing is normally performed from the bottom up. The smallest controlled software modules, the units, are tested individually. They are then combined or integrated and tested in larger aggregate groups or "builds". When this process is complete, the software system is tested in its entirety during the Developmental Test and Evaluation phase of the test program. The tested and approved system is known as the Initial Operational Configuration.

The usual software test program first verifies the adherence of the code to the detailed design (unit test), then to the top level design (integration), and finally to the system requirements themselves (developmental test). The operational test further validates the adherence of the code to the basic system requirements, as well as validating the requirements themselves against the real world environment. Obviously, as errors are found in the latter stages of the test program, it requires a return to earlier portions of the development program to provide corrections. The cost impact of error detection and correction can be diminished using the bottom up testing approach.

Software evaluation will be included in the assessment of the overall system suitability and effectiveness during critical milestone reviews. This is especially important for the test and evaluation of software embedded within mission critical computer resources belonging to major weapons systems.

It is critical that adequate software T&E information be contained in documents such as TEMPS and test plans. The TEMP must define characteristics of critical software components that effectively address goals and thresholds for mission critical functions. The measures of effectiveness (MOEs) must support the critical software issues. The test plan should specify the test methodologies which will be applied. Test methodologies consist of two components. The first is the test strategy which guides the overal testing effort and the second is the testing technique which is applied within the framework of a test strategy.

12.5.2 RAM/HUMAN FACTORS EVALUATION

A formal assessment of reliability, availability and maintainability (RAM) must be planned for each phase of development and operational testing. Important software characteristics include:

(1) Reliability: This characteristic is often a key indicator of software suitability. It is very important to choose measurement criteria that adequately reflect software reliability. Interim reliability goals must be established for each acquisition phase so that reliability requirements can be assessed during the entire acquisition process. Since time dependent, reliability goals are not really meaningful for software, goals should be stated in terms of observed time between operational mission failure. These measures include, but are not limited to:

(a) Mean-Time-Between-Operational-Mission Failure (MTBOMF) This measure can be used as an indicator of system suitability prior to deployment and as a control measure to track corrective actions, after the start of system level testing. For the measure to be meaningful, evaluation criteria must be established for each system load level.

(b) Mean-Time-Between-Loss-of-Function (MTBLOF) - This is a measure of functional reliability, measuring the time between occurrences when software does not perform a designed function.

(c) Mean-Time-To-Restore Function (MTTRF) - This measures time between loss of function and restoration of that function. In terms of software, it is not a corrective action, but rather a restorative function that requires maintenance or software input change. Corrective action may be required to prevent recurrence of the loss of function.

(d) Percent of Functions Verified and Validated - This measure indicates the degree software and system function have been tested. In order to achieve a statistical confidence level through probability distribution, the true operational distribution of the inputs must be known.

(2) Availability and Maintainability: Hardware-oriented definitions of availability and maintainability are generally not applicable to software system. This is due, in large part, to the fact that hardware oriented logistics parameters do not apply to software availability. Maintainability of software incorporates repair and re-engineering. Usually maintenance is carried out at a Post Deployment Software Support (PDSS) facility and factors limiting mean time to repair tend to revolve around communications and the labor-intensiveness of the maintenance process. To determine maintainability, the following software characteristics must be evaluated:

(a) Modularity - For ease of understanding and modification, is the software logically partitioned into parts or components with few and simple connections between parts?
(b) Descriptiveness - For understandability, does the source code and its documentation discuss the software objectives, assumptions, inputs, processing, outputs, components, and revision status?
(c) Consistency - Are standards and conventions followed in documentation, input/output processing, error processing, module interfacing, module/variable naming, etc.?
(d) Simplicity - To keep the code simple, are such characteristics as large numbers of operators, operands, and nested control structures, dynamic storage allocation and recursive/reentrant coding avoided?
(e) Expandability - is flexibility provided through parameterization of constants and basic data structure sizes?
(f) Instrumentation - Does the software provide for the inclusion of testing aids either through embedded test code or through a support software system?

(3) Human Factors: As an indicator of operational suitability, human factors can be evaluated early. The use of simulators, prototype hardware, and operator personnel can give reliable indications of software suitability. Early determination of deficiencies allows correction through redesign of the software. Later detection of unsuitable human factors in the software can raise the

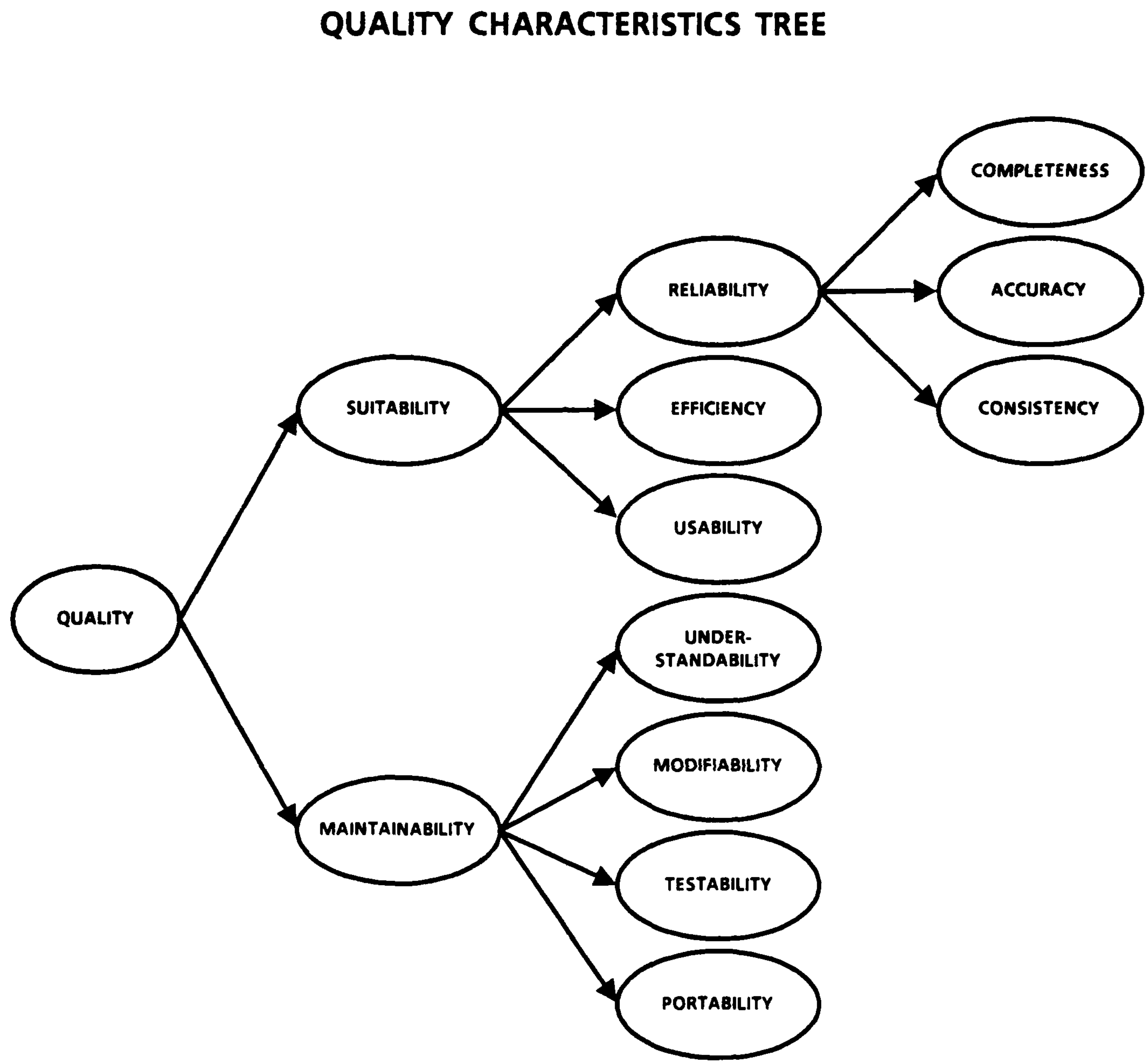
cost of correction considerably. An analysis of human factors requires an evaluation of software operator-machine interface in a way which will yield a consistent, quantifiable analysis of various aspects including:

(a) Assurability - Is sufficient redundancy and acknowledgement of user input required to ensure accuracy?
(b) Controllability - Can the user/operator make adjustments to such items as level of detail of help information and output report, or stop processing when incorrect inputs have been applied?
(c) Workload reasonability - Can the operator at each position or workstation stay abreast of the software processing, supplying inputs and recording results as necessary?
(d) Descriptiveness - Does the software provide adequate information for operator understanding and use?
(e) Consistency - Are identical operator-machine interface conventions used at each operator station?
(f) Simplicity - Are user options useable and not excessive? Are error diagnostics straightforward? It is also important that personnel responsible for evaluating software documention and module source listings have similar backgrounds to those who will maintain the software.

Effective test methodologies require realistic software test environments and scenarios. The test scenarios must be appropriate for the test objectives. That is, are the test results interpretable in terms of software test objectives. The test scenarios and analysis should actually verify and validate accomplishment of requirements. The test environments must be chosen on a careful analysis of characteristics to be demonstrated and its relationship to the development, operational and support environments. In addition, environment must also be representative of the environment in which the software will actually be maintained.

12.6 SOFTWARE QUALITY ASSURANCE

A comprehensive software quality program plan (SQPP) provides an effective method of controlling software development risk. The two major characteristics of software quality are suitability and maintainability. Below this there are sub-characteristics, as shown in the decision tree in Figure 12-4. There are both proactive and reactive approaches to software quality. Both approaches need to be applied for any MCCR or software intensive system. The proactive approach prevents error propagation through the following means:



SOURCE: <u>CHARACTERISTICS OF SOFTWARE QUALITY,</u>
B. BOEHM, ET. AL.

*7-1-MCL2-000584-19

Figure 12-4. Software Quality Characteristics

- o <u>Methods</u>
  - oo Structured System Analysis
  - oo Structured Design
  - oo Structured Programming

- o <u>Practices</u>
  - oo Program Library
  - oo Change Control
  - oo Coding Standards

- o <u>Tools</u>
  - oo Software Development Facility
  - oo Higher Order Language
  - oo Diagnostic Compiler
  - oo Code Standards Auditor

The reactive approach focuses on improving software quality once code is being or has been developed. This approach is achieved through the following methods, practices and tools:

- o <u>Methods</u>
  - oo Requirements Modeling
  - oo Simulation
  - oo Interface Analysis
  - oo Traceability Analysis

- o <u>Practices</u>
  - oo Design Review and Walkthroughs
  - oo Code Reading
  - oo Formal Test

- o <u>Tools</u>
  - oo Simulators
  - oo Dynamic Debugging Tools
  - oo Path Analyzer

The principal guide for software quality program is DoD-STD-2168, "Defense System Software Quality". This specification applies to software alone and to software as part of other systems. The software quality program requirements under include addressing the following:

1. Work tasking and authorization procedures,
2. Configuration management,
3. Testing plan and procedures,
4. Corrective actions,
5. Library controls,
6. Critical design reviews,

7. Software documents,
8. Reviews and audits and,
9. Tools, techniques and methodologies.

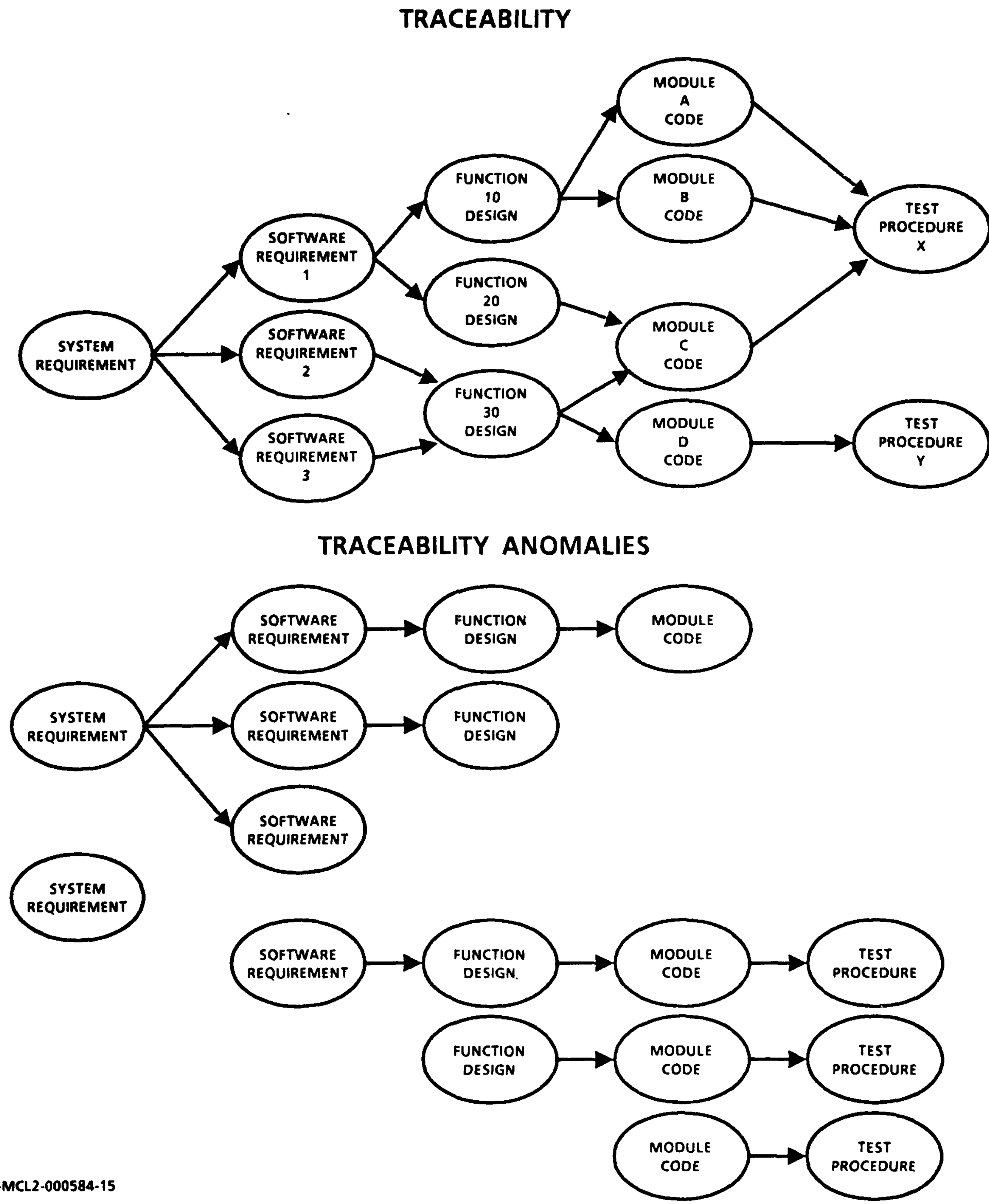
12.6.1 The Software Quality Environment

A Software Quality Program plan must be capable of tracing requirements through the development process. Traceability tables (Figure 12-5) are used to document and trace requirements through all phases of software development. These tables provide a tool with which to identify and integrate the requirements as well as the responsibilities, resources, schedules and critical issues associated with an embedded system. This analysis should also include a summary of key functions, interfaces and unique characteristics of the system in order to satisfy operational objectives. System requirements must be traced through the entire T&E process.

The advantages of performing requirements traceability are:

(1) The degree to which the design follows the requirements can be assessed.
(2) Error propagation can be reduced.
(3) Any requirement can be traced through the complete system acquisition process. Figure 12.6 provides an illustration of how a hierarchical set of traceability tables or matrices could appear in the system. These tables would serve as an index into documentation providing the capability to proceed along a specific thread or train of thought in the review process.
(4) Misplaced or invalid requirements are considered anomalies and can be detected early using requirements analysis and matrices.

To perform an adequate risk assessment, the degree to which software implements critical functions must be evaluated. The primary concern in this evaluation is to ensure that the software has been given a balanced treatment with other critical system components. Those software components that fulfill a requirement for a Key Function, as described in the TEMP, should be identified as critical software components. The risk assessment should also include an evaluation of the support software. As part of this effort, a software assessment correlation matrix should be developed which maps software functional specifications to technical risk areas. The correlation matrix (or equivalent narrative) is the primary source of information about how capabilities have been partitioned between hardware and software. These partitions will be important in determining required characteristics, in defining error/failure categories, and in isolating and correcting deficiencies noted during testing. Therefore, it may be important to determine that proper engineering studies



7-1-MCL2-000584-15

Figure 12-5. Traceability and Traceability Anomalies

TEST RESULTS		
TEST	STATUS	REPORT
T107	PASS	R-T107
T108	PENDING	

CODE/TEST PROCEDURES				
SOFTWARE DESIGN (C-5 LEVEL)	TEST PROCEDURES			
3.4.1 DATA BASE UPDATE MODULE	T107	T108	T117	T233a

SOFTWARE DESIGN/CODE			
SOFTWARE DESIGN (C-5 LEVEL)	MODULE/SUBROUTINES		
3.4.1 DATA BASE UPDATE MODULE	DBUR	DBCHK	

SOFTWARE REQUIREMENTS/DESIGN	
SYSTEM SPECIFICATION (B-5 LEVEL) REQUIREMENTS	SOFTWARE DESIGN (C-5 LEVEL)
3.7.2.1a READ CEP FROM IMPACT MODULE	3.4.1 DATA BASE UPDATE MODULE

SYSTEM SOFTWARE REQUIREMENTS			
SYSTEM SPECIFICATION (A LEVEL) REQUIREMENT	SYSTEM SPECIFICATION (B-5 LEVEL) REQUIREMENTS		
3.1.1 DISPLAY CEP	3.7.2.1a	3.7.2.1b	3.7.4
3.2.3 ACCEPT WEAPON TIME-OF-FLIGHT	3.4.2		
3.2.4 ISSUE PREARM COMMAND	3.5.1	3.6.2	

*7-1-MCL2-000584-17

Figure 12-6. Example of Traceability Tables have led to the establishment of these partitions. An understanding of the sources of risk in each of the software-implemented functions identified in the correlation matrix is an essential part of the overall risk assessment.

12.6.2 Independent Verification and Validation

Independent verification and validation (IV&V) is a risk reducing technique which is applied to major software development efforts. The primary purpose of independent verification and validation is to ensure that software meets requirements and is reliable and maintainable. IV&V is only effective if implemented early in the software development schedule. Requirements analysis and risk assessment are the most critical activities performed by IV&V organizations their effectiveness is limited if brought on board a project after the fact. Often, there is a reluctance to implement IV&V because of the costs involved, but early implementation of IV&V will result in lower overall costs of error correction and software maintenance. As development efforts progress, IV&V involvement typically decreases due more to the expense of continued involvement rather than a lack of need. For an IV&V program to be effective, it must be the responsibility of an individual or organization external to the software development program manager.

The application of the IV&V process to software development maximizes the maintainability of the fielded software system, while minimizing the cost of developing and fielding it. Maintenance of a software system falls into several major categories: corrective maintenance, modifying software to correct errors in operation; adaptive maintenance, modifying the software to meet changing requirements; and perfective maintenance, modifying the software to incorporate new features or improvements.

The IV&V process maximizes the reliability of the software product, which eases the performance of and minimizes the need for corrective maintenance. It also attempts to maximize the flexibility of the software product, which eases the performance of adaptive and perfective maintenance. These goals are achieved primarily by determining at each step of the software development process that the software product completely and correctly meets the specific requirements determined at the previous step of development. This step-by-step, iterative process continues from the initial definition of system performance requirements all the way through final acceptance testing.

The review of software documentation at each stage of development is a major portion of the verification process. The current documentation is a description of the software product at the present stage of development and will define the requirements laid on the software product at the following stage. Careful examination and analysis of the development documentation ensures that each step in the software design process is consistent with the previous step. Omissions, inconsistencies, or design errors can then be identified and corrected as early as possible in the development process.

Continuing participation in formal and informal design reviews by the IV&V organization maintains the communication flow between software system "customers" and developers, assuring that the software design and production proceed with minimal delays and misunderstandings. Frequent informal reviews, design and code walk-throughs and audits ensure that the programming standards, software engineering standards, software quality assurance and configuration management procedures designed to produce a reliable, maintainable operational software system are indeed followed throughout the process. Continuous monitoring of computer hardware resource allocation throughout the software development process also ensures that the fielded system has adequate capacity to meet operation and maintainability requirements.

The entire testing process, from the planning stage through final acceptance test is also approached in a step-by-step manner by the IV&V process. At each stage of development, the functional requirements determine test criteria as well as design criteria for the next stage. An important function of the IV&V process is to ensure that the test requirements derive directly from the performance requirements independent of design implementation. Monitoring of, participation in, and performance of the various testing and inspection activities by the IV&V contractor ensure that the developed software meets requirements at each stage of development.

Throughout the entire software development process, the IV&V contractor reviews any proposals for software enhancement or change, proposed changes in development baselines and proposed solutions to design or implementation problems to ensure that the original performance requirements are never lost sight of. An important facet of the IV&V contractor's role is to act as the objective third party continuously maintaining the "audit trail" from the initial performance requirements to the final operational system.

12.7 SUMMARY

There is a useful body of software testing technologies which can be applied to testing of embedded systems. As a technical discipline, though, software testing is still maturing. Currently, there is little to guide the program manager in choosing one testing technique over another. It is apparent that systematic test and evaluation techniques are far superior to ad-hoc testing techniques. Implementation of an effective test and evaluation plan requires a set of strong technical and management controls. Given the increasing number of embedded computer systems being acquired, there will be an increased emphasis on tools and techniques for test and evaluation.

CHAPTER 13

EW/C² TEST AND EVALUATION

13.1 INTRODUCTION

Testing of electronic warfare (EW) and command and control (C^2) systems poses unique problems for the tester because of the difficulty in measuring their performance in operational terms. Special testing techniques and facilities are normally required in EW and C^2 testing. This chapter discusses the problems associated with EW and C^2 testing and presents methodologies the tester can consider using to overcome the problems.

13.2 TESTING EW SYSTEMS

13.2.1 Special Consideration When Testing EW Systems

The purposes of EW systems are to increase survivability, degrade enemy capability, and contribute to the overall success of the combat mission. Decision makers want to know the incremental contribution to total force effectiveness made by a new EW system, which is a force-on-force issue. However, the contractual specifications for EW systems are usually stated in terms of engineering parameters such as effective radiated power, reduction in communications intelligibility, and jamming-to-signal ratio; these measures are of little use by themselves in assessing contribution to mission success. The decision makers require that testing be conducted under realistic operational conditions, but the major field test ranges, such as the shoreline at Eglin AFB or the desert at Nellis AFB, cannot provide the signal density or realism of threats that would be presented by a Soviet Combined Arms Army in the Fulda Gap in Central Europe. In field testing, the tester can achieve one-on-one or, at best, few-on-few testing conditions. To do this he needs a methodology that will permit extrapolation of engineering measurements and one-on-one test events to create more operationally meaningful measures of mission success in a force-on-force context.

13.2.2 Integrated Test Approach

An integrated approach to EW testing using a combination of large-scale models, computer simulations, hybrid man-in-the-loop simulators, and field test ranges is a solution for the EW tester. No single one of these tools by itself is adequate to provide a comprehensive evaluation. Simulation, both digital and hybrid, can provide a means for efficient test execution. Computer models can be used to simulate many different test cases to aid the tester in assessing the critical test issues (i.e., sensitivity analysis) and produce a comprehensive set of predicted results. As digital simulation models are validated with empirical data from testing, they can be used for evaluation of the system under test in a more dense and complex threat environment and at expected wartime levels. In addition, the field test results are used to validate the model, and the model is also used to validate the field tests, thus lending more credibility to both results. Hybrid man-in-the-loop simulators, such as the Real-Time Electromagnetic Digitally Controlled Analyzer and Processor (REDCAP) and the Air Force Electronic Warfare Evaluation Simulator (AFEWES) can provide a capability to test against new threats. Hybrid simulators are also cheaper and safer than field testing. The field test ranges are used when a wider range of actions and reactions by both aircraft and ground threat system operations is required.

Where one tool is weak, another may be strong. By using all the tools, an EW tester can do a more complete job of testing. The integrated methodology is shown in Figure 13-1. EW integrated testing can be summarized as:

(1) Initial modeling phase for sensitivity analysis and test planning.
(2) Active test phases at hybrid laboratory simulator and field range facilities.
(3) Test data reduction and analysis.
(4) Post-test modeling phase repeating the first step using test data for extrapolation.
(5) Force effectiveness modeling and analysis phase to determine the incremental contribution of the new system to total force effectiveness.

13.3 TESTING OF C² SYSTEMS

13.3.1 Special Considerations When Testing C² Systems

The purpose of a C² system is to provide a commander with timely and relevant information to support sound decision making. A variety of problems face the C² system tester. However, in evaluating command effectiveness, it is difficult to separate the contribution made by the C² system from the contribution made by the commander's innate, cognitive processes. To assess a C² system in its operational environment, it must be connected to the other systems with which it would normally operate, making traceability of test results difficult. Additionally, modern C² systems are software intensive and highly interactive, with complex man-machine interfaces. Measuring C² system effectiveness thus requires the tester to use properly trained user troops during the test and to closely monitor software T&E. C² systems of the Army, Navy, Air Force, and Marines are expected to interoperate with each other and with those of the NATO forces; hence, the tester must also ensure inter-Service

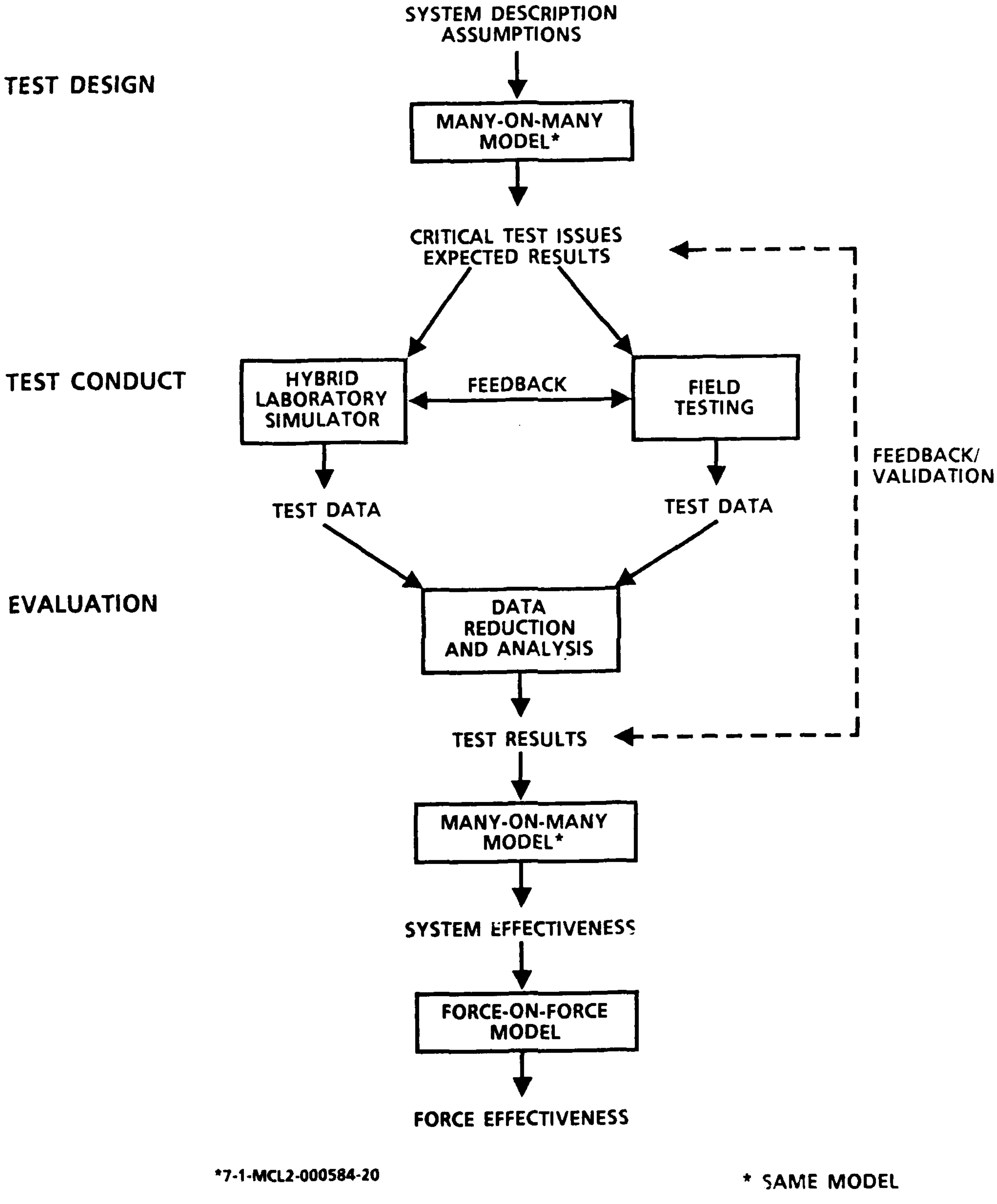


Figure 13-1. Integrated EW Testing Approach

and NATO compatibility and interoperability.

13.3.2 C² Test Facilities

Testing of C^2 systems will have to rely more on the use of computer simulations and C^3I test beds to assess their overall effectiveness. The Joint Tactical Command, Control, and Communications Agency (JTC^3A) which is responsible for ensuring interoperability among all U.S. tactical C^3 systems that would be used in joint or combined operations, operates the Joint Test Element (JTE) in Ft. Huachuca, Arizona. The JTE is a testbed for C^3I systems interoperability. Another facility, the huge testbed developed at Kirtland AFB, New Mexico for the Identification Friend, Foe, or Neutral (IFFN) Joint Test, will be operated by the Air Force and be available for use by the development and operational communities of all the Services for their C^3I testing needs.

13.4 CURRENT TRENDS IN TESTING C² SYSTEMS

13.4.1 Evolutionary Acquisition of C² Systems

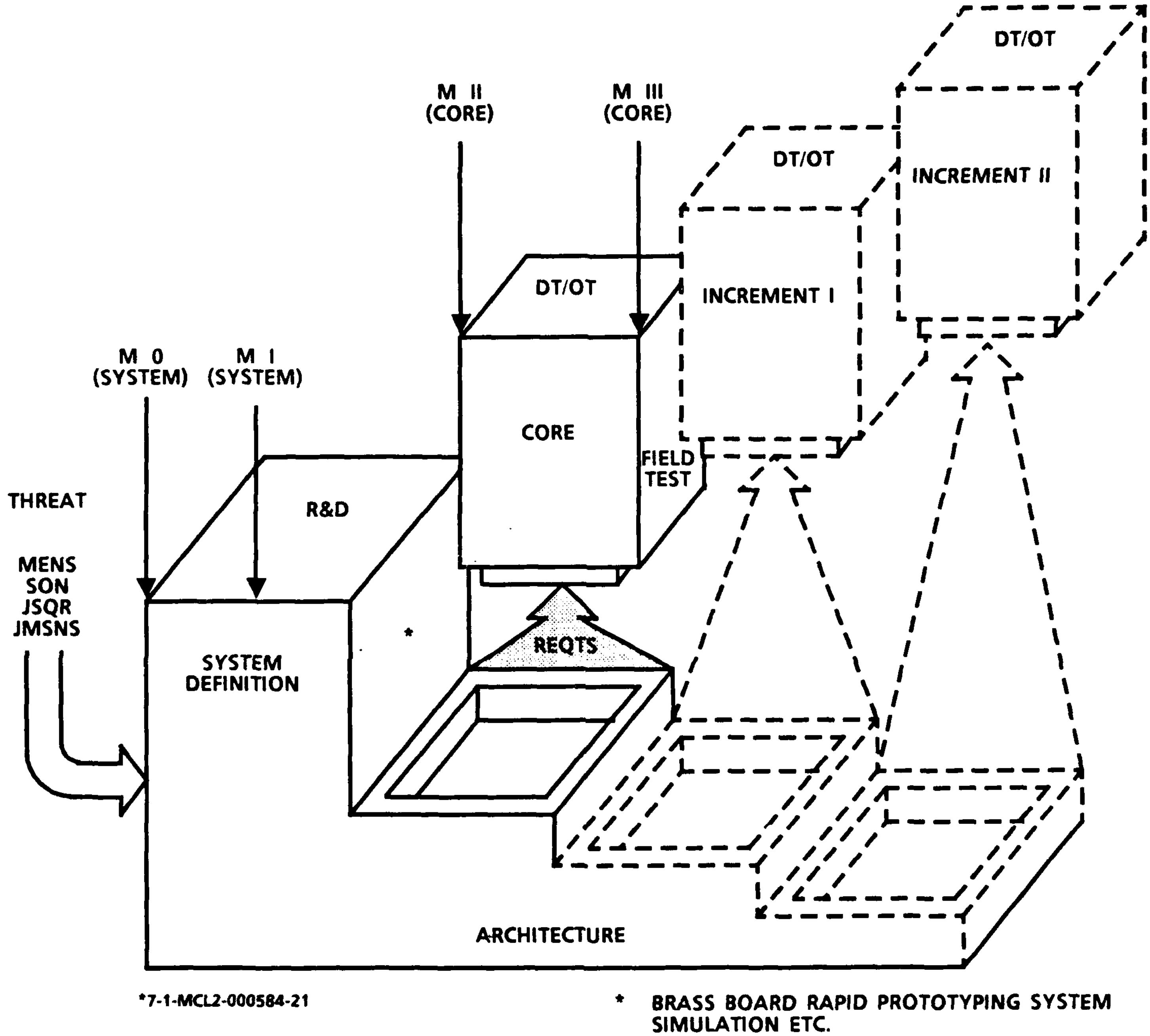
Evolutionary Acquisition (EA) is a strategy designed to provide an early, useful capability even thougn detailed overall system requirements cannot be fully defined at the program's inception. EA contributes to a reduction in the risks involved in system acquisition, since the system is developed and tested in manageable increments. C^2 systems are likely candidates for EA because they are characterized by system requirements which are difficult to quantify or even articulate and which are expected to change as a function of scenario, mission, theater, threat, and emerging technology. Therefore, the risk associated with developing these systems can be very great.

Recent studies by the Defense Systems Management College and the International Test and Evaluation Association (ITEA) have addressed the issues involved in the evolutionary acquisition and testing of C^2 systems. The ITEA study illustrated EA in Figure 13-2, and stated that:

> With regard to the tester's role in EA, the study group concluded that iterative test and evaluation is essential for success in an evolutionary acquisition. The tester must become involved early in the acquisition process and contribute throughout the development and fielding of the core and the subsequent increments.... The testers contribute to the requirements process through feedback of test results to the user...and...must judge the ability of the system to evolve (Reference 4).

THE EVOLUTIONARY ACQUISITION PROCESS

ARCHITECTURE AND CORE MILESTONES



SOURCE: ITEA STUDY, "TEST & EVALUATION OF C² SYSTEMS DEVELOPED BY EVOLUTIONARY ACQUISITION"

Figure 13-2. The Evolutionary Acquisition Process

The testing of Evolutionary Acquisition (EA) Systems presents the tester with a unique challenge as he must test the core system during fielding and the first increment before the core testing is completed. This could lead to a situation where the tester has three or four tests ongoing on various increments of the same system. The Program Manager must insist that the testing for EA systems be carefully planned to ensure the test data is shared by all and there is a minimum of repetition or duplicity in testing.

13.4.2 Radio Vulnerability

The Radio Vulnerability Analysis (RVAN) Methodology is a recently developed methodology for assessing the anti-jam capability and limitations of radio frequency data links when operating in a hostile electronic countermeasures environment. In 1983, OSD directed the Services to apply the Data Link Vulnerability Analysis (DVAL) methodology to all new data links being developed.

The purpose of the DVAL methodology is to identify and quantify the anti-jam capabilities and vulnerabilities of an RF data link operating in a hostile electronic countermeasures (ECM) environment. The methodology is applied throughout the acquisition process and permits early identification of needed design modifications to reduce identified ECM vulnerabilities. The following four components determine a data link's EW vulnerability:

(1) The <u>susceptibility</u> of a data link, i.e., the receiver's performance when subjected to intentional threat ECM;
(2) The <u>interceptibility</u> of the data link, i.e., the degree to which the transmitter could be intercepted by enemy intercept equipment;
(3) The <u>accessibility</u> of the data link, i.e., the likelihood that a threat jammer could degrade the data link's performance; and

(4) The <u>feasibility</u> that the enemy would intercept and jam the data link and successfully degrade its performance.

The analyst applying the DVAL methodology will require test data, and the test manager of the C^3I system of which the data link is a component, will be required to provide this data.

13.5 SUMMARY

EW systems must be tested under conditions representative of the dense threat signal environments in which they will operate. C^2 systems must be tested in representative environments where their interaction and responsiveness can be demonstrated. The solution for the tester is an integrated approach using a combination of analytical models, computer simulations, hybrid laboratory simulators and test beds, and actual field testing. The tester must understand these test techniques and resources and apply them in EW and C^2 test and evaluation.

CHAPTER 14

LOGISTICS INFRASTRUCTURE T&E

14.1 INTRODUCTION

In all materiel acquisition programs, the Integrated Logistics Support (ILS) effort begins in the mission area analysis phase prior to program initiation, continues throughout the entire acquisition cycle, and extends past the deployment phase. Logistics testing must therefore extend over the entire acquisition cycle of the system and be carefully planned and executed to ensure the readiness and supportability of the system. This chapter covers the development of logistics support test requirements and the conduct of supportability assessments to ensure that readiness and supportability objectives are identified and achieved. The importance of the ILS Manager's participation in the TEMP development process should be stressed. He must ensure the ILS T&E objectives are considered and that adequate resources are available for ILS T&E.

Integrated Logistic Support (ILS) is defined as a disciplined, unified, and iterative approach to the management and technical activities necessary to: integrate support considerations into system and equipment design; develop support requirements that are related consistently to readiness objectives, to design, and to each other; acquire the required support; provide the required support during the operational phase at minimum cost (DoD 5000.39).

ILS consists of ten specific components, or elements:

(1) Maintenance planning
(2) Manpower and personnel
(3) Supply support
(4) Support equipment
(5) Technical data
(6) Training and training support
(7) Computer resources support
(8) Facilities
(9) Packaging, handling, storage, and transportation
(10) Design interface

14.2 PLANNING FOR ILS T&E

14.2.1 Objectives of ILS T&E

The main objective of ILS test and evaluation is to verify that the logistic support being developed for the materiel system is capable of meeting the required objectives for both peacetime and wartime employment. ILS T&E consists of the usual DT&E and OT&E, but also includes post-deployment supportability assessments. The formal DT&E and OT&E begin in the concept exploration phase and continue into the production/deployment phase. Figure 14-1, which appears in the DSMC Integrated Logistics Support Guide, describes the specific DT, OT, and supportability assessment objectives for each acquisition phase.

14.2.2 Planning Documentation for ILS T&E

14.2.2.1 Integrated Logistic Support Plan

The ILS Manager for a materiel acquisition system is responsible for developing the Integrated Logistic Support Plan (ILSP), which is the primary document for planning and implementing the support of the fielded system. It is initially prepared during the Concept Exploration phase, then is progressively developed in more detail as the system moves through the acquisition phases. Included in the ILSP is identification of the specific ILS test issues related to the individual ILS elements and the overall system support and readiness objectives.

The ILS Manager is assisted throughout the system's development by the Integrated Logistics Support Management Team (ILSMT), which is formed early in the acquisition cycle. The ILSMT is a coordination/advisory group comprised of personnel from the Program Management office, the using command, and other commands concerned with acquisition activities such as logistics, testing, and training.

14.2.2.2 Supportability Assessment Plan

Based upon the ILSP objectives, the ILS Manager, in conjunction with the system's test manager, develops the Supportability Assessment Plan, which identifies the testing approach and the evaluation criteria that will be used to assess the supportability-related design requirements (e.g. reliability and maintainability) and adequacy of the planned logistic support resources for the materiel system. Development of the Supportability Assessment Plan begins in the Concept Exploration phase; the plan is then updated and refined in each successive acquisition phase. The ILS tester applies the techniques of Logistic Support Analysis, as described in MIL-STD-1388-1A, to formulate the test and evaluation strategy, establish the T&E program objectives and criteria and identify required test resources. He must ensure that his T&E strategy is based upon quantified supportability requirements and will address supportability issues which have a high degree of risk associated with them. He must also ensure that the necessary quantities and types of data will be collected to validate the various T&E objectives, both during system development and after deployment of the system. The T&E objectives and criteria must provide a basis upon which to ensure that critical supportability issues and requirements are resolved or achieved within acceptable confidence levels.

TEST TYPE / ACQUISITION PHASE	CONCEPT EXPLORATION/ DEFINITION	CONCEPT DEMONSTRATION/ VALIDATION	FULL SCALE DEVELOPMENT	FULL-RATE PRODUCTION/DEPLOYMENT	OPERATIONAL SUPPORT
DEVELOPMENT T&E	• SELECT PREFERRED SYSTEM AND SUPPORT CONCEPTS	• IDENTIFY PREFERRED TECHNICAL APPROACH, LOGISTIC RISKS, AND PREFERRED SOLUTIONS	• IDENTIFY DESIGN PROBLEMS AND SOLUTIONS IN RE: - SURVIVABILITY - COMPATIBILITY - TRANSPORTATION - R&M - SAFETY - HUMAN FACTORS	• ASSURE PRODUCTION ITEMS MEET DESIGN REQUIREMENTS AND SPECIFICATIONS	• ASSURE ADEQUACY OF SYSTEM DESIGN CHANGES
OPERATIONAL T&E AND SUPPORTABILITY ASSESSMENT	• ASSESS OPERATIONAL IMPACT OF CANDIDATE TECHNICAL APPROACHES • ASSIST IN SELECTING PREFERRED SYSTEM AND SUPPORT CONCEPTS • ESTIMATE OPERATIONAL COMPATIBILITY AND SUITABILITY	• EXAMINE OPERATIONAL ASPECTS OF ALTERNATIVE TECHNICAL APPROACHES • ESTIMATE POTENTIAL OPERATIONAL SUITABILITY OF CANDIDATE SYSTEMS	• ASSESS OPERATIONAL SUITABILITY - OPERATIONAL R&M - BUILT-IN DIAGNOSTIC CAPABILITY - TRANSPORTABILITY • EVALUATE LOGISTICS SUPPORTABILITY - EFFECTIVENESS OF MAINTENANCE PLANNING - APPROPRIATE PERSONNEL SKILLS/GRADES - APPROPRIATE SPARES, REPAIR PARTS, BULK SUPPLIES - ADEQUATE SUPPORT EQUIPMENT, INCLUDING EFFECTIVE ATE AND SOFTWARE - ACCURATE AND EFFECTIVE TECHNICAL DATA; VALIDATION/ VERIFICATION OF TECHNICAL MANUALS - ADEQUATE FACILITIES (SPACE, ENVIRONMENTAL SYSTEMS, STORAGE) - EFFECTIVE PACKAGING, LIFTING DEVICES, TIE-DOWN POINTS, TRANSPORTATION INSTRUCTIONS	• ASSURE PRODUCTION ITEMS MEET OPERATIONAL SUITABILITY REQUIREMENTS	• DEMONSTRATE ATTAINMENT OF SYSTEM READINESS OBJECTIVES • UPDATE O&S COST ESTIMATES • EVALUATE OPERATIONAL SUITABILITY AND SUPPORTABILITY OF DESIGN CHANGES • IDENTIFY IMPROVEMENT REQUIRED IN SUPPORTABILITY PARAMETERS • PROVIDE DATA REQUIRED TO ADJUST ILS ELEMENTS

*7-2-MCL2-000185-04

Figure 14-1. ILS Objectives in the T&E Program

SOURCE: DSMC, INTEGRATED LOGISTICS SUPPORT GUIDE, MAY 1986.

14.2.2.3 Test and Evaluation Master Plan (TEMP)

The Program Manager must include ILS T&E information in the TEMP, as specified in DoD 5000.3-M-1. The input, which is derived from the Supportability Assessment Plan with the assistance of the ILS Manager and the tester, includes descriptions of required operational suitability, specific plans for testing logistics supportability, and required testing resources. It is of critical importance that all test resources required for all ILS testing (DT, OT, and post-deployment supportability) be identified in the TEMP, because the TEMP is the basis upon which test resources are budgeted and allocated for testing.

14.2.3 Planning Guidelines for Logistic T&E

The following guidelines for ILS T&E are extracted from the DSMC ILS Guide:

(1) Develop a test strategy for each ILS-related objective. Ensure that OT&E planning encompasses all ILS elements. The general ILS objectives shown in Figure 14-1 must be translated into detailed quantitative and qualitative requirements for each acquisition phase and each T&E program.

(2) Incorporate ILS testing requirements (where feasible) into the formal DT&E/OT&E plans.

(3) Identify ILS T&E that will be performed outside of the normal DT&E and OT&E. Include subsystems that require off-system evaluation.

(4) Identify all required resources, to include test articles and logistic support items for both formal DT/OT and separate ILS testing (participate with test planner).

(5) Ensure establishment of an operationally realistic test environment, to include personnel representative of those who will eventually operate and maintain the fielded system. These personnel should be trained for the test using prototypes of the actual training courses and devices and should be supplied with drafts of all technical manuals and documentation that will be used with the fielded system.

(6) Ensure planned OT&E will provide sufficient data on high cost and high maintenance burden items (e.g., for high cost critical spares, early test results can be used to re-evaluate selection).

(7) Participate early and effectively in the TEMP development process to ensure the TEMP includes critical logistic T&E and omission of needed ILS test funds from program and budget documents.

(8) Identify the planned utilization of all data collected during the assessments to avoid mismatch of data collection and information requirements.

Detailed evaluation criteria for each of the ten ILS elements listed above are presented in Department of the Army Pamphlet 700-50, "Integrated Logistic Support: Developmental Supportability Test and Evaluation Guide."

14.3 CONDUCTING ILS T&E

14.3.1 Scope

The purposes of ILS T&E are to measure the supportability of a developing system throughout the acquisition process; to identify supportability deficiencies and potential corrections/improvements as test data becomes available; and to assess the operational effectiveness of the planned support system. ILS T&E also evaluates the system's operational suitability and its ability to achieve planned readiness objectives for the system/equipment being developed. Specific ILS T&E tasks (as prescribed in MIL-STD-1388-1A) include:

- Analysis of test results to verify achievement of specified supportability requirements.
- Determination of improvements in supportability and supportability-related design parameters needed for the system to meet established goals and thresholds.
- Identification of areas where established goals and thresholds have not been demonstrated within acceptable confidence levels.
- Development of corrections for identified supportability problems such as modifications to hardware, software, support plans, logistic support resources, or operational tactics.
- Projection of changes in costs, readiness and logistic support resources due to implementation of corrections.
- Analysis of supportability data from the deployed system to verify achievement of the established goals and

thresholds and where operational results deviate from projections, determination of the causes and corrective actions.

ILS T&E may consist of a series of ILS demonstrations and assessments which are usually conducted as part of system performance tests. Special end-item equipment tests are rarely conducted solely for ILS evaluation.

14.3.2 T&E of System Support Package

T&E of the support for a materiel system requires a system support package consisting of spares, support equipment, technical documents and publications, representative personnel, any peculiar support requirements, and the test article itself; in short, all of the items that would eventually be required when the system is operational. This complete support package must be at the test site before the test is scheduled to begin. Delays in the availability of certain support items could prevent the test from proceeding on schedule (which can be costly due to on-site support personnel on hold or tightly scheduled system ranges and expensive test resources not being properly utilized) or could result in the test proceeding without conducting the complete evaluation of the support system. The ILS test planner must ensure that the required personnel are trained and available, that test facility scheduling is flexible enough to permit normal delays, and that the test support package is on site on time.

14.3.3 Data Collection and Analysis

The ILS Manager must coordinate with the testers to ensure that the methods used for collection, storage, and extraction of ILS T&E data are compatible with those used in testing the materiel system. As with any testing, the ILS test planning must ensure that all required data is identified; that it is sufficient to evaluate a system's readiness and supportability; and that plans are made for a data management system that is capable of the data classification, storage, retrieval, and reduction necessary for statistical analysis.

14.3.4 Use of ILS Test Results

The emphasis on the use of the results of testing changes as the program moves from the CE Phase to post deployment. During early phases of a program, the evaluation results are used primarily to verify analysis and develop future projections. As the program moves into FSD and hardware becomes available, the evaluation addresses design, particularly the reliability and maintainability aspects, training programs, support equipment adequacy, personnel skills and availability, and technical publications.

The ILS Manager must make the Program Manager (PM) aware of the impact on the program of logistical shortcomings which are identified during the T&E process. The PM in turn must ensure that the solutions to any shortcomings are identified and reflected in the revised specifications and that the revised test requirements are included in the updated Test and Evaluation Master Plan (TEMP) as the program proceeds through the various acquisition stages.

14.4 LIMITATIONS TO ILS T&E

Concurrent testing or tests that have accelerated schedules frequently do not have sufficient test articles, equipment or hardware to achieve statistical confidence in the testing conducted. The shortage of equipment is often the reason that shelf life and service life testing is cut short, leaving the ILS evaluator with insufficient data to predict future performance of the test item.

14.5 SUMMARY

Test and Evaluation are the logisticians' tools for measuring the ability of the planned support system to fulfill the materiel system's readiness and supportability objectives. The effectiveness of ILS T&E is based upon the completeness and timeliness of the planning effort.

ILS T&E requirements must be an integral part of the TEMP to ensure budgeting and scheduling of required test resources. Data requirements must be completely identified, with adequate plans made for collection, storage, retrieval, and reduction of test data.

CHAPTER 15

PRODUCTION RELATED TESTING ACTIVITIES

15.1 INTRODUCTION

Most of the T&E discussed in this guidebook concerns the testing of the actual weapon or system being developed. But the Program Manager (PM) must also evaluate production related test activities and the production process itself. This chapter describes production management and the production process testing required to ensure the effectiveness of the manufacturing process and the producibility of the system's design. Normally, the DT and OT organizations are not involved directly in this process. Usually, the Manufacturing and Quality Assurance sections of the program office, along with the Program Manager, oversee/perform many of these functions.

15.2 PRODUCTION MANAGEMENT

Production management is defined as "the effective use of resources to produce, on schedule, the required number of end items that meet specified quality, performance, and cost. Production management includes, but is not limited to, industrial resource analysis, producibility assessment, producibility engineering and planning, production engineering, industrial preparedness planning, post-production planning, and productivity enhancement" (DODD 4245.6). Production management begins early in the acquisition process, as early as the Concept Exploration phase, and is specifically addressed at each program milestone decision point. For instance, during the Concept Exploration/Definition phase (CE), production feasibility, costs, and risks should be addressed. Prior to Milestone I, the PM must conduct an industrial resource analysis (IRA) to determine the availability of production resources (e.g., capital, material, manpower) required to support the production of the weapon system. Based upon the results of the IRA, critical materials, deficiencies in the U.S. industrial base, and requirements for new or updated manufacturing technology can be identified. Analysis of the industrial base capacity is one of the considerations in preparing the System Concept Paper for the Milestone I decision. As development proceeds, the manufacturing strategy is developed, and detailed plans are made for the production phase. Independent producibility assessments, conducted in preparation for the transition from development to production, are reviewed at the Milestone II decision point. At Milestone II, the Full-Scale Development decision, the producibility of the system design concept is evaluated to verify that the system can be manufactured in compliance with the production cost and the industrial base goals and thresholds.

The Milestone III Full Rate Production decision is supported by an assessment of the readiness of the system to enter production. The system cannot enter the Full-Rate Production/Deployment phase until it is determined that the principal contractors have the necessary resources (i.e., physical, financial, and managerial capacity) to achieve the cost and schedule commitments and to meet both peacetime and mobilization requirements for production of the system. The method of assessing production readiness in preparation for Milestone III is the Production Readiness Review (PRR), which is conducted by the PM and staff. An independent assessment of production readiness is conducted at the same time by the DoD Product Engineering Services Office (DPESO) of Deputy Director Defense Research and Engineering (DDDR&E). The DPESO reports its findings directly to the Defense Acquisition Executive.

15.3 PRODUCTION READINESS REVIEWS

The policy, procedures, and guidelines for PRRs are delineated in DODD 5000.38, which states "the objective of a PRR is to verify that the production design, planning, and associated preparations for a system have progressed to the point where a production commitment can be made without incurring unacceptable risks of breaching thresholds of schedule, performance, cost, or other established criteria." The PRR must confirm that the system design is stable and producible; that adequate manufacturing technology exists; that the necessary manufacturing methods, techniques, and processes are available to the producer; and that suitable provisions have been made for manufacturing, cost, and quality control.

The conduct of a PRR is the responsibility of the PM, who usually appoints a director. The director then assembles a team made up of individuals with design, industrial, manufacturing, procurement, inventory control, contracts, the engineering disciplines, and quality training experience. The PRR director organizes and manages the team effort and supervises preparation of the findings. The PRR is conducted as a time-phased effort during the Full-Scale Development phase following the guidelines presented in DODD 5000.38. Table 15-1 summarizes these guidelines in a checklist format.

15.4 QUALIFICATION TESTING

Qualification Testing is performed to verify the design and manufacturing process, and it provides a baseline for subsequent acceptance tests. The production qualification testing is conducted at the unit, sub-system, and system level on production items and is completed before the production decision. The results of these tests are a critical factor in assessing the system's readiness for production. There are normally preproduction and production qualification tests. Downline production qualification tests are performed to verify process control and may be performed on selected parameters rather than at the levels originally selected for qualification.

15.4.1 Preproduction Qualification Tests (PPQT)

Preproduction Qualification Tests are a series of formal contractual tests conducted to ensure design integrity over the specified operational and environmental range. The tests are conducted on prototype or preproduction items fabricated to the proposed production design drawings and specifications. The PPQTs include all contractua[illegible] lity and maintainability demonstration tests required prior to [illegible]tion release. For volume acquisitions, these tests are a constraint to production release.

Table 15-1. PRR Guidelines Checklist

<u>Product Design</u>

- Producible at low risk
- Stabilized at low rate of change
- Validated
- Reliability, maintainability, performance demonstrated
- Components engineering has approved all parts selections

<u>Industrial Resources</u>

- Adequate plant capacity (peacetime and wartime demands)
- Facilities, special production and test equipment, tooling identified
- Needed plant modernization (CAD/CAM, other automation) accomplished which produces an invested captive payback in two to five years
- Associated computer software developed
- Skilled personnel and training programs available

<u>Production Engineering and Planning</u>

- Production plan developed (reference MIL-STD-1528)
- Production schedules compatible with delivery requirements
- Manufacturing methods and processes integrated with facilities, equipment, tooling, and plant layout
- Value engineering applied
- Alternate production approaches available
- Drawings, standards, and shop instructions are explicit
- Configuration management adequate
- Production policies and procedures documented
- Management information system adequate
- Contractor's management structure is acceptable to the PMO
- The PEP checklist has been reviewed

Table 15-1. PRR Guidelines Checklist (Concluded)

<u>Materials</u>

- All selected materiels approved by contractor's Materiel Engineers
- Bill of materials prepared
- "Make-or-Buy" decisions complete
- Procurement of long lead-time items planned
- Sole source and government furnished items identified
- Contractor's inventory control system adequate
- Contractor's material cost procurement plan complete

<u>Quality Assurance</u>

- Quality plan in accordance wht contract requirements
- Quality control procedures and acceptance criteria established
- QA organization participates in production planning effort

<u>Logistics</u>

- Operational support, tes and diagnostic equipment available at system deployment
- Training aids, simulators, other devices ready at system deployment
- Spares integrated into production lot flow

15.4.2 Production Qualification and Production Acceptance Tests

Production Qualification and Production Acceptance Tests consist of a series of formal contractual tests conducted to ensure the effectiveness of the manufacturing process, equipment, and procedures. These tests are conducted on a random sample from the first production lot. These series of tests are repeated if the manufacturing process, equipment, or procedures are changed significantly and when a second or alternative source of manufacturing is brought on line.

15.5 TRANSITION TO PRODUCTION

In an acquisition process, often the first indications that a system will experience problems is during the transition from Full Scale Development to Full-Rate Production/Deployment. This transition continue over an extended period, often months or years, and this is the period that the system is undergoing stringent contractor and Government testing. There may be unexpected failures that require significant design changes, and these changes may impact on quality, producibility, supportability, and may require program schedule slippages.

Long periods of transition usually indicate that insufficient attention to design or producibility needs were not made as early as Combat Exploration or the Demonstration/Validation phases.

15.5.1 The Transition Plan

The Transition Plan is the common thread that guides a system from CE to production. The plan is a management tool which ensures that adequate risk handling measures have been taken to transition from development to production. It contains a checklist to be used during the readiness reviews. The plan should tie together the applications of design, test, and manufacturing activities in order to reduce data requirements, duplication of effort, cost and schedule, and assure an early success of the FSD first production article.

15.5.2 Testing During the Transition

Testing accomplished during the transition from development to production will include the Acceptance Testing, Manufacturing Screening, and Final testing. These technical tests are performed by the contractor to ensure that the system will transition smoothly, and that test design and manufacturing issues affecting design and design issues are addressed. During this same period, the Government will be conducting the Initial Operational Test and Evaluation, which can be conducted in two phases during the transition, using the latest available configuration item. The impact of these tests may overwhelm the configuration management of the system unless careful planning is accomplished to handle these changes.

15.6 LOW RATE INITIAL PRODUCTION (LRIP)

Systems may be produced in a limited quantity to be used in OT&E for verification of production engineering; and design maturity and to establish a production base. Test and evaluation is conducted on these systems to verify that the production process provides materiel that meets the required technical and operational performance requirements of the system. When the decision authority thinks that the systems will not perform to expectation, he will direct that it not proceed beyond low-rate initial production. The Director, Operational Test & Evaluation submits a report, on all major systems, to Congressional Committees before the Milestone III decision to proceed beyond LRIP is made.

15.7 PRODUCTION ACCEPTANCE TEST & EVALUATION (PAT&E)

Production Acceptance Test & Evaluation assures that production items demonstrate the fulfillment of the requirements and specifications of the procuring contract or agreements. The testing also ensures the system being produced demonstrates the same performance as the preproduction models. The procured items or system must operate in accordance with Type A (system) and Type C (production) specifications. PAT&E is usually conducted by the Quality Assurance section of the program office at the contractor's plant and may involve operational users.

> For example, for the Rockwell B-1B Bomber production acceptance, both Rockwell and Air Force Quality Assurance inspectors reviewed all manufacturing and ground testing results for each aircraft. In addition, a flight test team composed of both contractor and Air Force test pilots flew each aircraft a minimum of 10 hours, demonstrating in flight all on-board aircraft systems. Any discrepancies in flight were noted, corrected and tested on the ground, then retested on subsequent checkout and acceptance flights. Once each aircraft had passed all tests and all systems were fully operational, Air Force authorities accepted the aircraft. The test documentation also became part of the delivered package. During this test period, the program office monitored each aircraft's daily progress.

15.8 SUMMARY

A primary purpose of production related testing is to lower the production risk in a major defense acquisition program. The Program Manager must ensure that the contractor's manufacturing strategy and capabilities will result in the desired product within acceptable cost. LRIP and PAT&E also play major roles in ensuring the production unit is identical to the preproduction units and conforms to the specifications of the contract.

MODULE V

TEST AND EVALUATION ISSUES

Many Program Managers face several test and evaluation issues that must be resolved to get their particular weapon system tested and ultimately fielded. These issues may include modeling and simulation support; combined and concurrent testing; test resources; survivability and lethality testing; multiservice testing; or international T&E. Each of these issues presents a unique set of challenges for the Program Manager.

CHAPTER 16

MODELING AND SIMULATION SUPPORT TO T&E

16.1 INTRODUCTION

This chapter discusses the applications of modeling and simulation in test and evaluation. The need for modeling and simulation has long been recognized, as evidenced by this quote from the USAF Scientific Advisory Board in June 1965:

> Prediction of combat effectiveness can only be, and therefore must be, made by using the test data in analytical procedures. This analysis usually involves some type of model, simulation, or game (i.e., the tools of operations or research analysis). It is the exception and rarely, that the 'end result' i.e., combat effectiveness, can be deduced directly from test measurements.

DoD 5000.3, in mandating T&E early in the acquisition process (i.e., prior to Milestone II), encourages the use of modeling and simulation as a source of T&E data. For instance, the Armored Family of Vehicles program is using more than sixty models, simulations and other test data to support system concept exploration. The reliance on modeling and simulation by this and other acquisition programs provides the T&E community with valuable information which can increase confidence levels, decrease field test time and costs, and provide data for pre-test prediction and post-test validation.

This chapter demonstrates that proper selection, application, and use of modeling and simulation can increase the efficiency of the T&E process, reduce the time and cost, provide otherwise unattainable and unmeasurable data, and provide more timely and valid results.

16.2 TYPES OF MODELS AND SIMULATIONS

The term "modeling and simulation" is often associated with huge digital computer simulations, but it also includes manual and man-in-the-loop war games, test beds, hybrid laboratory simulators, and prototypes.

A mathematical model is an abstract representation of a system that provides a means of developing quantitative performance requirements from which candidate designs can be developed. Static models are those that depict conditions of state, while dynamic models depict conditions that vary with time, such as the action of an autopilot in controlling an aircraft. Simple dynamic models can be solved analytically, and the results represented graphically.

According to a former Director, Defense Test and Evaluation, (Reference 121), simulations used in T&E can be divided into three categories: computer simulations, system test beds, and system prototypes. Computer simulations are strictly mathematical representations of systems and do not employ any actual hardware. They may, however, incorporate some of the actual software that might be used in a system. Early in a system's life cycle, computer simulations can be expected to provide the most system evaluation information. In many cases, computer simulations can be readily developed as modifications of existing simulations for similar systems. For example, successive generations of AIM-7 missile simulations have been effectively used in test and evaluation.

A system test bed usually differs from a computer simulation in that it contains some, but not necessarily all, of the actual hardware that will be a part of the system. Other elements of the system are either not incorporated or are incorporated in the form of computer simulations. The system operating environment (including threat) may either be physically simulated, as in the case of a flying test bed, or it may be computer simulated, as in the case of a laboratory test bed. Aircraft cockpit simulators used to evaluate pilot performance are good examples of system test beds. As development of a system progresses, more and more subsystems become available in hardware form. These subsystems can then be incorporated into system test beds that typically provide a great deal of the system evaluation information used during the middle part of a system's development cycle.

The third type of simulation used in test and evaluation is the system prototype. Unlike the system test bed, all subsystems are physically incorporated in a system prototype. The system prototype may come reasonably close to representing the final system configuration depending on the state of development of the various subsystems which compose it. Preproduction prototype missiles and aircraft used in operational testing by the Services are examples of this class of simulation. As system development proceeds, eventually all subsystems will become available for incorporation in one or more system prototypes. Operational testing of these prototypes frequently provides much of the system evaluation information needed for a decision on full scale production and deployment.

There is a continuous spectrum of simulation types, as illustrated in Figure 16-1, with the pure computer simulation at one end and the pure hardware prototype at the other end.

16.3 VALIDITY OF MODELING AND SIMULATION

Simulations are not a substitute for live testing. There are many things that cannot be adequately simulated by computer programs

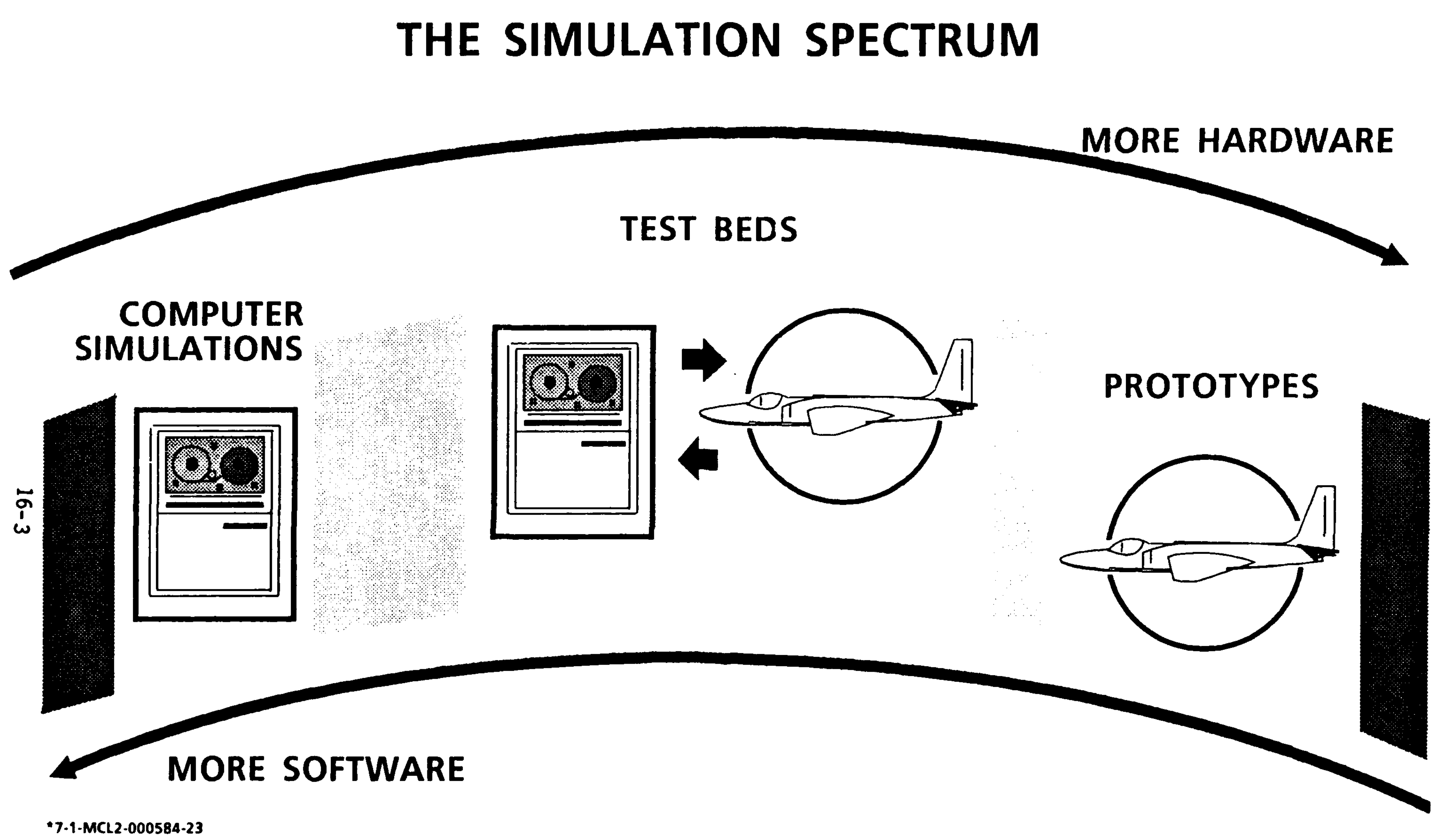


Figure 16-1. The Simulation Spectrum

- among them the process of decision and the proficiency of personnel in the performance of their functions. Therefore, there is no possible substitution for physical tests and evaluations. Simulations, both manual and computer designed, however, can complement and increase the validity of live tests and evaluations by proper selection and application. Figure 16-2 contrasts the test criteria which are conducive to modeling and simulation versus physical testing. Careful selection of the simulation, knowledge of its application and operation, and meticulous selection of input data will produce representative and valid results.

The important element in using a simulation is to select one that is representative and either addresses or is capable of being modified to address the level of detail (the essential elements of analysis and objectives) under investigation.

16.4 SUPPORT TO TEST DESIGN AND PLANNING

Modeling and simulation can assist in the T&E planning process and can reduce the cost of the conduct of testing. Areas of particular application include scenario development and the timing of test events; the development of objectives, essential elements of analysis, and measures of effectiveness; the identification of variables for control and measurement, and the development of data collection, instrumentation and data analysis plans. For example, using simulation, the test designer can examine system sensitivities to changes in variables to determine the critical variables and their ranges of values to be tested. He can also predict ahead of time the effects of various assumptions and constraints and evaluate candidate measures of effectiveness to help in formulation of the test design.

Caution must be exercised when planning to rely on simulations as a means of obtaining test data as they tend to be very expensive to develop, difficult to integrate with data from other sources, and often do not provide the level of realism required for operational tests. Although simulations are not a "cure all" they should be used whenever feasible as another source of data for the evaluator to consider during the test evaluation.

Computer simulations may be used to test the planning for an exercise. By setting up and running the test exercise in a simulation, the timing and scenario may be tested and validated. Critical events may be identified to include the interaction of the various forces which test the measures of effectiveness, the essential elements of analysis and, in turn, the test objectives. Further, the simulation may be used to verify the statistical test design, the instrumentation plan, the data collection plan, and the data analysis plan. Essentially, the purpose of the computer simulation in pre-test planning is to pre-test the test to make test results more effective. Pre-testing attempts to optimize

CRITERIA	VALUES CONDUCIVE TO: PHYSICAL TESTING	MODELING AND SIMULATION
TEST SAMPLE SIZE/NUMBER OF VARIABLES	SMALL/FEW	LARGE/MANY
STATUS OF VARIABLES/UNKNOWNS	CONTROLLABLE	UNCONTROLLABLE
PHYSICAL SIZE OF PROBLEM	SMALL AREA/FEW PLAYERS	LARGE AREA/MANY PLAYERS
AVAILABILITY OF TEST EQUIPMENT	AVAILABLE	UNAVAILABLE
AVAILABILITY OF TEST FACILITIES	RANGES, OTHER TEST AVAILABLE	BENCHMARKED, VALIDATED, COMPUTER MODELS AVAILABLE
TYPES OF VARIABLES/UNKNOWNS	SPATIAL/TERRAIN	LOW IMPORTANCE OF SPATIAL/TERRAIN
DIPLOMATIC/POLITICAL FACTORS	CONVENTIONAL CONFLICTS	NUCLEAR OR CHEMICAL CONFLICTS

*7-1-MCL2-000584-35

Figure 16-2. Values of Selected Criteria Conducive to Modeling and Simulation test results by pointing out potential trouble spots. It constitutes a test setup analysis which can encompass a multitude of areas.

As an example of simulations used in test planning, consider a model which portrays aircraft versus air defenses. The model can be used to replicate typical scenarios and provide data on the number of engagements, the air defense systems involved, the aircraft target, the length and quality of the engagement and a rough approximation of the success of the mission (i.e., did the aircraft make it to the target?). With such data available, a data collection plan can be developed to specify in more detail when and where data should be collected, from which systems, and in what quantity. The results of this analysis impact heavily on long lead time items such as data collection devices and data processing systems. The more specificity available, the fewer the number of surprises which will occur downstream. As tactics are decided upon and typical flight paths are generated for the scenario, an analysis can be done on the flight paths over the terrain in question and a determination can be made whether or not the existing instrumentation can track the numbers of aircraft involved in their maneuvering envelopes. Alternative siting arrangements can be examined and trade-offs can be made between the amount of equipment to be purchased and the types of profiles which can be tracked for this particular test. Use of such a model can also highlight numerous choices available to the threat air defense system in terms of opportunities for engagement, and practical applications of doctrine to the specific situations.

16.5 SUPPORT TO TEST EXECUTION

Simulations can be useful in test execution and dynamic planning. With funds and other restrictions limiting the number of times that a test may be repeated and each test conducted over several days, it is mandatory that the test director exercise close control over the conduct of the test to ensure that data to meet the test objectives are being gathered and to ensure adequate safety. He must be able to make minor modifications to the test plan and scenario to force achievement of these goals. This calls for a dynamic (quick-look) analysis capability and a dynamic planning capability. Simulations may contribute to this capability. For example, using the same simulation(s) as used in the pre-test planning, the tester could input data gathered during the first day of the exercise to determine the adequacy of the data to fulfill the test objectives. Using this data, the entire test could be simulated. Projected inadequacies could be isolated and the test plans modified to minimize the deficiencies.

Simulations may also be used to support test control and to assure safety. For example, during recent missile test firings at White Sands Missile Range (WSMR), aerodynamic simulations of the proposed test were run on a computer during actual firings so that real time missile position data could be continuously compared to the simulated missile position data. If any significant variations occurred, and if the range safety officer were too slow (both types of position data were displayed on plotting boards), the computer issued a destruct command.

Simulations can be used to augment tests by simulating non-testable events and scenarios. Although operational testing should be accomplished in as realistic an operational environment as possible, pragmatically some environments are impossible to simulate for safety or other reasons. Some of these include the environment of a nuclear battlefield to include the effects of nuclear bursts on both friendly and enemy elements. Others include two-sided live firings and adequate representation of other forces to ascertain compatibility and interoperability data. Instrumentation, data collection, and data reduction of large combined arms forces (e.g., brigade, division, and larger-sized forces) become extremely difficult and costly. Simulations are not restricted by safety factors and can realistically play many of the environments that are otherwise unachievable in an OT&E - nuclear effects, large combined forces, ECM and ECCM, and many-on-many engagements.

Usually, insufficient units are available to simulate the organizational relationships and interaction of the equipment with its operational environment, particularly during the early OT&E conducted using prototype or pilot production type equipment. Simulations are not constrained by these limitations. Data obtained from a limited test can be plugged into a simulation which is capable of handling many of the types of equipment being tested and interfacing them with other elements of the blue forces and operating them against large elements of the red forces to obtain interactions.

Simulations can also play design characteristics of equipment and can be used to augment the results obtained using prototype or pilot production type equipment that is "mocked-up" to represent the final item. The simulation may be used to improve the "mocked-up" representation or to indicate that the prototype equipment will not satisfy the requirements of the test.

It is often necessary to use "substitute" equipment in testing e.g., American equipment is used to represent threat force equipment. In some cases the substitute equipment may have greater capabilities than the real equipment; in other cases, less. Simulations are capable of representing the real characteristics of equipments and, therefore, can be used as a means of modifying raw data collected during the test to reflect real characteristics.

> As an example, suppose the substitute equipment is an AAA gun with a tracking rate of 30 degrees per second, whereas the equipment for which it

is substituted has a tracking rate of 45 degrees per second. The computer simulation could be used to augment the collected, measured data by determining how many rounds could have actually been fired against each target or whether targets that were missed because of too slow tracking rate could have been engaged by the actual equipment. Consideration of other differing factors simultaneously could have a plus or minus synergistic effect on test results.

16.6 SUPPORT TO ANALYSIS AND TEST REPORTING

Modeling and simulation may be used in post-test analysis to extend and generalize results and to extrapolate to other conditions. The difficulty of controlling large exercises, not to mention the difficulty in instrumenting them and collecting and reducing the data, to some degree limits the size of OT&E. This makes the process of determining the operational suitability of equipment to include compatibility, interoperability, organization, etc., a difficult one. To a large degree the interactions, interrelationships, and compatibility of large forces may be obtained by using actual data collected during the test and applying it to the simulation.

Simulations can be used to extend test results and to save considerable energy (both fuel and manpower) and money by precluding the need to rerun to improve the statistical sample, or to determine overlooked or directly unmeasured parameters.

In analyzing the test results, they can be compared to the results predicted by the simulations used early in the planning process. Thus, the simulation is validated by the actual live test results, but the test results are also validated by the simulation.

16.7 SUMMARY

Modeling and simulation in T&E can be used for concept evaluation, extrapolation, isolation of effects, efficiency, representation of complex environments, and overcoming inherent limitations in live testing. The use of modeling and simulation can validate test results, increase confidence levels, reduce test costs, and shorten the overall acquisition cycle by providing more data earlier for the decision maker.

MODULE VI

MANAGEMENT OF TEST AND EVALUATION

Test and Evaluation is a management tool and an integral part of the development process. This module will address the policy structure and oversight mechanisms in place for test & evaluation. It will also address the program office responsibilities for development test & evaluation and for operational test & evaluation. The module will conclude with the T&E of certain weapon system types and outline the unique character and planning requirements of each.

The module will also address the T&E from an international perspective and will describe the OSD-sponsored program to manage the testing of foreign weapon systems.

CHAPTER 17

COMBINED AND CONCURRENT TESTING

17.1 INTRODUCTION

The terms "concurrency," "concurrent testing," and "combined testing" are sometimes subject to misinterpretation. For the purpose of this discussion, "concurrency" is defined as an approach to system development and acquisition in which two phases of the acquisition process, which normally occur sequentially, overlap to some extent. For example, a weapon system enters the production phase while development efforts are still underway.

The term "concurrent testing" refers to circumstances when development testing and operational testing take place at the same time, as two parallel but clearly separate and distinct activities. In contrast, "combined testing" refers to a single test program conducted to support both development test and operational test objectives. This chapter discusses the use of combined testing and concurrent testing and highlights some of the advantages and disadvantages associated with these approaches.

17.2 COMBINING DT AND OT

Certain test events can be organized to provide information that is useful to both development testers and operational testers. For example, a prototype free-fall munition could be released from a fighter aircraft at operational employment conditions to satisfy both development and operational test objectives. Such instances need to be identified to prevent unnecessary duplication of effort and to control costs. A combined testing approach is also appropriate for certain specialized types of testing. For example, in the case of nuclear survivability and hardness testing, systems cannot be tested in a totally realistic operational environment, therefore, a single test program is often used to meet both development and operational test objectives.

DoD Directive 5000.3 encourages combined testing and states that "a combined DT&E and OT&E approach may be used when cost and time benefits are significant and are clearly identified, provided that test objectives are not compromised." If this approach is elected, planning efforts must be carefully coordinated early in the program to ensure that data is obtained to satisfy the needs of both the developing agency and the independent operational tester. Care must also be exercised to ensure that a combined test program contains dedicated operational test events to satisfy the requirement for an independent evaluation. The final period of testing before the full-rate production decision will be separate OT&E managed by the independent operational test agency. In all combined test programs, separate independent development and operational evaluations of test results must be provided.

Service regulations describe the sequence of activities in a combined testing program as follows:

> Although IOT&E is separate and distinct from DT&E, most of the generated data are mutually beneficial and freely shared. Similarly, the resources needed to conduct and support both test efforts are often the same or very similar. Thus, when sequential DT&E and IOT&E efforts would cause delay or increase the acquisition cost of the system, DT&E and IOT&E are combined. When combined testing is planned, the necessary test conditions and data required by both DT&E and OT&E organizations must be integrated. Combined testing can normally be divided into three segments. In the first segment, DT&E event[s] usually assume priority because critical technical and engineering tests must be accomplished to continue the engineering and development process. During this early period, OT&E personnel participate to gain familiarity with the system and to gain access to any test data that can support IOT&E. Next, the combined portion of the testing frequently includes shared objectives or joint data requirements. The last segment normally contains the dedicated IOT&E or separate IOT&E events to be conducted by the OT&E agency. The OT&E agency and implementing command must ensure the combined test is planned and executed to provide the necessary operational test information. The OT&E agency provides an independent evaluation of the IOT&E portion and is ultimately responsible for achieving OT&E objectives.

The testing of the Navy's F-14 aircraft has been cited as an example of a successful combined T&E program (Reference 112). A key factor in the success of the F-14 approach was the selection of a T&E coordinator responsible for supervising the generation of test plans that integrated the technical requirements of the developers with the operational requirements of the users. The T&E coordinator was also responsible for the allocation of test resources and the overall management of the test. In a paper for the Defense Systems Management College, Mr. Thomas Hoivik describes the successful F-14 test program as follows:

> The majority of the Navy developmental and operational testing took place during the same period and even on the same flights. Maximum use was made of contractor demonstrations witnessed by the Navy testing activities to obviate the retesting of a technical

point already demonstrated by the contractor. Witnessing by testing activities was crucially important and allowed the contractor's data to be readily accepted by the testing activities. This approach also helped to eliminate redundancy in testing, i.e. the testing of the same performance parameter by several different activities which has been a consistent and wasteful feature Navy testing in the past.

Obviously, this approach placed a great deal of responsibility directly on the shoulders of the T&E Coordinator, and required his staff to deal knowledgeably with a wide-ranging and complex test plan.

17.3 CONCURRENT TESTING

In 1983, a senior DoD test and evaluation official testified that a concurrent testing approach is usually not an effective strategy (Reference 106). He acknowledged, however, that certain test events may provide information useful to both development and operational testers and that test planners must be alert to identify those events. His testimony included the following examples of situations where a concurrent testing approach was unsuccessful:

(1) During AAH (Advanced Attack Helicopter) testing in 1981, the Target Acquisition Designation System (TADS) was undergoing developmental and operational testing at the same time. The schedule did not allow enough time for qualification testing (a development test activity) of the TADS prototype prior to a full field test of the total aircraft system, nor was there time to introduce changes to TADS problems discovered in tests. As a result, the TADS performed poorly and was unreliable during the operational test. The resulting DSARC action required the Army to fix and retest the TADS prior to release of second year and subsequent production funds.

(2) When the AIM-7 Sparrow air-to-air missile was tested an attempt was made to move into operational testing while developmental reliability testing was still underway. The operational test was suspended after less than two weeks because of poor reliability of the test missiles. The program concentrated on an intensive reliability improvement effort. A year

after the initial false start, a full operational test was conducted and completed successfully.

(3) The Maverick missile had a similar experience of being tested in an operational environment before component reliability testing was completed. As a result, reliability failures had a major impact on the operational testers and resulted in the program being extended.

17.4 ADVANTAGES AND LIMITATIONS

Before adopting a combined or concurrent testing approach, program and test managers are advised to consider the advantages and disadvantages summarized in Table 17-1.

17.5 SUMMARY

A combined or concurrent testing approach may offer an effective means for shortening the time required for testing and also for achieving cost savings. If such an approach is used, extensive coordination is required to ensure both the development and operational requirements are addressed.

It is possible to have combined test teams, consisting of both DT&E and OT&E personnel, involved throughout the testing process. The teams can provide mutual support and share mutually beneficial data, as long as the test program is carefully planned, evaluated and reporting activities are conducted separately.

Table 17-1. Combined and Concurrent Testing: Advantages and Limitations

Combined Testing

Advantages	Limitations
• Shortens time required for testing and thus, the acquisition cycle.	• Requires extensive early coordination.
• Achieves cost savings by eliminating redundant activities.	• Test objectives may be compromised.
• Early involvement of OT&E personnel during system development increases their familiarity with system.	• Requires development of DT/OT common test data base.
• Early involvement of OT&E personnel permits communication of operational concerns to developer in time to allow changes in system design.	• If system design is unstable and far reaching modifications are made, OT&E must be repeated.
	• Combined testing programs are often conducted in a development environment.
	• Test will be difficult to design to meet both DT & OT requirements.
	• Contractor personnel frequently perform maintenance functions in a DT&E. The system contractor is prohibited by law from participating in OT&E.
	• Time constraints may result in less coverage than planned for OT&E objectives.

Concurrent Testing

Advantages	Limitations
• Shortens time required for testing and thus, the acquisition cycle.	• Requires extensive coordination.
• Achieves cost savings by eliminating redundant activities.	• If system design is unstable and far reaching modifications are made, OT&E must be repeated.
• Involvement of OT&E personnel permits communication of operational concerns to developer in time to allow changes in system design.	• Concurrent testing programs are often conducted in a development environment.
	• Contractor personnel frequently perform maintenance functions in a DT&E. The system contractor is prohibited by law from participating in OT&E.
	• Time constraints may result in less coverage than planned for OT&E objectives.

CHAPTER 18

TEST RESOURCES

18.1 INTRODUCTION

This chapter describes the various types of resources available for testing, explains test resource planning in the Services, and discusses the ways in which test resources are funded.

According to DoD 5000.3-M-1, the term "test resources" is a "collective term that encompasses all elements necessary to plan, conduct, collect and analyze data from a test event or program." These elements include funding (to develop new or use existing resources), manpower for test conduct and support, test articles, models, simulations, threat simulators, surrogates, replicas, test beds, special instrumentation, targets, tracking and data acquisition instrumentation, and equipment for data reduction, communications, meteorology, utilities, photography, calibration, security, recovery, maintenance and repair, frequency management and control, and base/facility support services.

Existing test resources are in great demand by competing acquisition programs. Often special, unique or one-of-a-kind test resources must be developed specifically for the test program. It is imperative that the requirements for these test resources be identified early in the acquisition cycle so that adequate funding can be allotted for their development and their use can be scheduled.

18.2 OBTAINING TEST RESOURCES

18.2.1 Major Range and Test Facility Base

All of the Services operate ranges and test facilities for test, evaluation, and training purposes. Twenty-one of these activities constitute the DoD Major Range and Test Facility Base (MRTFB), which is "a national asset which shall be sized, operated, and maintained primarily for DoD test and evaluation support missions, but also is available to all users having a valid requirement for its capabilities. The MRTFB consists of a broad base of T&E activities managed and operated under uniform guidelines to provide T&E support to DoD Components responsible for developing or operating materiel and weapon systems." (Reference 21). The list of MRTFB activities and their locations are shown in Figures 18-1 and 18-2. Summaries of the capabilities of each of these activities (with points of contact listed for further information) may be found in DoD 3200.11-D.

MAJOR RANGE AND TEST FACILITY BASE SUMMARY

White Sands Missile Range

Kwajalein Missile Range

Yuma Proving Ground

Dugway Proving Ground

Electronic Proving Ground

Aberdeen Proving Ground

Pacific Missile Test Center

Naval Air Test Center

Naval Weapons Center

Naval Air Propulsion Center

Atlantic Undersea Test and Evaluation Center

Atlantic Fleet Weapons Training Facility

Eastern Space and Missile Center

Western Space and Missile Center

Arnold Engineering Development Center

Tactical Fighter Weapons Center

Utah Test and Training Range

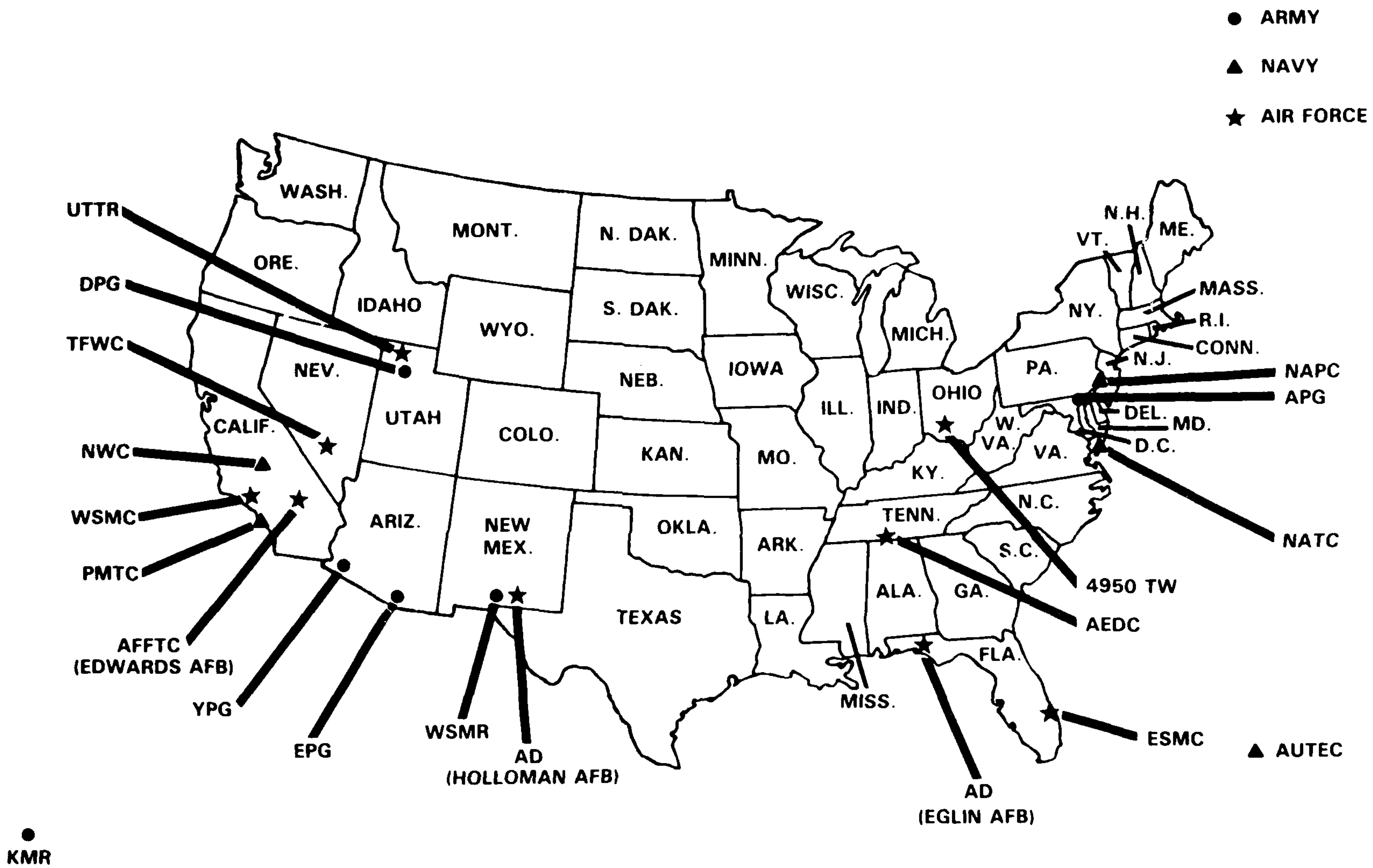
Armament Division - 3246th Test Wing

Armament Division - 6585th Test Group

Aeronautical Systems Division - 4950th Test Wing

Figure 18-1. DoD MRTFB

Source: DoD 3200.11-D



DOD MAJOR RANGE AND TEST FACILITY BASE LOCATION OF ACTIVITIES

Figure 18-2. DOD MRTFB Location of Activities

Source: DOD 3200.11-D

The MRTFB facilities are available for use by all the Services, other U.S. Government agencies, and, in certain cases, allied foreign governments and private organizations. Scheduling is based on a priority system and costs for usage are billed uniformly, as stated in DoD 3200.11. The Deputy Director, Defense Research and Engineering (T&E) sets policy for the composition, use, and test program assignments of the MRTFB. The individual Services must, in turn, fund, manage, and operate their activities. They are reimbursed by each user of the activity.

DoD components wisning to use an MRTFB activity must provide timely and complete notification of their requirements, such as special instrumentation or ground support equipment requirements, to the particular activity using the documentation formats prescribed by that activity. The requirements must be stated in the TEMP as will be discussed below. Personnel at the MRTFB activity will coordinate with prospective users to assist them in their T&E planning, to include conducting trade-off analyses and test scenario optimization based on test objectives and test support capabilities.

18.2.2 Service Test Facilities

There are other test resources available in addition to the MRTFB. The tester can determine current resources available within the Army by consulting documents such as the Army Test Facilities Register, the Operational Test and Evaluation Agency (OTEA), the Operational Test Instrumentation Guide, and other Army test agency and range documents. Information on specific Navy test resources is found in the users manuals published by each range and the Commander Operational Test and Evaluation Force (COMOPTEVFOR) catalog of available support.

18.3 TEST RESOURCE PLANNING

The development of special test resources to support a weapon system test can be costly and time consuming. This, coupled with the high demand for existing test resources and facilities, requires that early planning be accomplished to determine all test resource requirements for weapon system T&E. The tester must plan and conduct tests to take full advantage of the existing investment in the DoD ranges, facilities and test resources (collectively, the MRTFB).

Problems associated with range and facility planning are that priority systems tend to get top priority, i.e., B-1B, M-1, etc. Range schedules are often in conflict due to system problems which occur during testing, and there is often a shortage of funds to complete testing.

18.3.1 TEMP Requirements

The Program Manager must state all test resource requirements in the TEMP, and must include items such as unique instrumentation, threat simulators, surrogates, targets, and test articles. Included in the TEMP are a critical analysis of anticipated resource shortfalls, their effect on system T&E, and plans to correct resource deficiencies. The initial TEMP must be prepared before Milestone I, hence initial test resource planning must be accomplished during the concept exploration/ definition phase. Refinements and reassessments of test resource requirements are included in each annual and milestone TEMP update. The required content of the test resource summary section of the TEMP is in Part V - Test and Evaluation Resource Summary, DoD 5000.3-M-1.

18.3.2 Service Test Resource Planning

More detailed listings of required test resources are generated in conjunction with the detailed test plans written by the materiel developer and operational tester. These test plans describe test objectives, measures of effectiveness (MOE), scenarios, and specific test resource requirements.

18.3.2.1 Army Test Resource Planning

In the Army, the operational tester prepares the Test, Evaluation, Analysis, and Modeling (TEAM) plan and the Independent Evaluation Plan (IEP), which are the primary planning documents for OT&E of the weapon system. These documents, which should be prepared early in the acquisition cycle (at the beginning of the Concept Demonstration and Validation Phase), describe the entire T&E approach, including critical issues, test methodology, measures of effectiveness, and all necessary test resources. The TEAM Plan and IEP provide the primary inputs to the Outline Test Plan, which contains a detailed description of each identified required test resource, where and when it is to be provided, and the organization, usually the Forces Command (FORSCOM) or Training and Doctrine Command (TRADOC), that will provide the resource.

The tester must coordinate the Outline Test Plan (OTP) with all major commands or agencies expected to provide test resources. Then, the OTP is submitted to the Resource Management Division, HQ, OTEA, for review by the Test Schedule and Review Committee (TSARC) and incorporation into the Army's Five Year Test Program (FYTP). The initial OTP for each test should be submitted to the TSARC five years prior to the test's start date. Revised OTPs are submitted as more information becomes available or requirements change, but a final comprehensive version of the OTP should be submitted at least a year before the resources are required.

The TSARC is responsible for providing high-level centralized management of OT&E resource planning. The TSARC is chaired by the Commanding General OTEA, and consists of general officer or equivalent representatives from the Army staff and major commands. The TSARC meets semiannually to review all OTPs, resolve conflicts, and coordinate all identified test resource requirements for inclusion in the FYTP. The FYTP is a formal resource tasking document for current and near term tests and a planning document for tests scheduled for the out-years. All OTPs are reviewed during the semiannual reviews to ensure that any refinements or revisions are approved by the TSARC and reflected in the FYTP. The FYTP is produced as a hard copy document by OTEA and is also maintained in automated format on the TRADOC Resource Management System (TRMS). This system is maintained at Ft. Hood, Texas, with access terminals located at Army major headquarters and test boards.

The TSARC-approved OTP is a tasking document by which the tester requests Army test resources. The TSARC coordinates resource requests, sets priorities, resolves conflicts, and schedules resources. The resultant FYTP, when approved by the DCSOPS, HQ DA, is a formal tasking document that reflects the agreements made by the resource providers (AMC, TRADOC, FORSCOM, etc.) to make the required test resources available to the designated tests. If test resources from another Service, a non-DoD governmental agency (such as DOE or NASA), or a contractor are required, the request is coordinated by the OTEA Resource Management Division. For example, the request for a range must be made at least 2 years in advance to ensure availability. However, due to the long lead time required to schedule these non-Army resources, their availability cannot be guaranteed if the test is delayed or retesting is required. The use of resources outside the U.S., such as in Canada, Germany, or other NATO countries is also handled by OTEA.

18.3.2.2 Navy Test Resource Planning

In the Navy, the developing agency and the operational tester are responsible for identifying the specific test resources which are required in testing the weapon system. In developing the requirements for test resources, the Program Manager (PM) and Operational Test Director (OTD) refer to documents such as the MNS, SCP, DCP, Navy Decision Coordinating Paper (NDCP), Operational Requirement (OR), threat assessments, OPNAVINST 3960.10C (Test and Evaluation), and the OTD Guide (COMOPTEVFOR Instruction 3960.1D). Upon Chief of Naval Operations approval, the TEMP becomes the controlling management document for all T&E of the weapon system; it constitutes CNO direction to conduct the T&E program defined in the TEMP, including the commitment of Research, Development, Test and Evaluation financial support, and it commits fleet units and schedules. It is prepared by the Program Manager, with OT&E inputs provided by the COMOPTEVFOR Operational Test Director. The TEMP defines all T&E (DT&E, OT&E, and PAT&E) to be conducted for the system and describes the test resources required in as much detail as possible.

The Navy utilizes its operational naval forces to provide realistic T&E of new weapons systems. Each year, the CNO (OP-098) compiles all fleet support requirements for RDT&E program support from the TEMPs and publishes the CNO Long Range RDT&E Support Requirements document for the budget and out-years. In addition, a quarterly forecast of support requirements is published approximately 5 months before the Fleet Employment Scheduling Conference for the Quarter in which the support is required. These documents summarize OT&E requirements for Fleet services and are used by the Fleet for scheduling services and out-year budget projections.

Requests for use of range assets are usually initiated informally with a phone call from the PM and/or OTD to the range manager, followed by formal documentation. Requests for Fleet support are usually more formal. COMOPTEVFOR, in coordination with the PM, forwards the TEMP and a Fleet RDT&E Support Request to the CNO. Upon approval of the request, the CNO tasks the Fleet CINC by letter or message to coordinate with OPTEVFOR to provide the requested support.

Use of most Navy ranges must be scheduled at least a year in advance. Each range consolidates and prioritizes user requests, negotiates conflicts, and attempts to schedule range services to satisfy all requests. If the desired range services cannot be made available when required, the test must wait, or the CNO resolves the conflict. Because ranges are fully scheduled in advance, it is difficult to accommodate a test that is delayed or requires additional range time beyond that originally scheduled. Again, the CNO can examine the effects of delays or retest requirements and issue revised priorities, as required.

Requests for use of non-Navy OT&E resources are initiated by COMOPTEVFOR. OPTEVFOR is authorized direct liaison with the other Service independent operational test agencies (OTA) to obtain OTA-controlled resources. Requests for other government-owned resources are forwarded to the CNO (OP-098) for formal submission to the Service Chief (for Service assets) or to the appropriate government agency (e.g., DOE or NASA). Use of contractor resources is usually handled by the PM, although contractor assets are seldom required in OT&E, since the Fleet is used to provide an operational environment. Requests for use of foreign ranges are handled by the OP-098 Assistant for International R&D (OP-098F).

18.3.2.3 Air Force Test Resource Planning

The test resources required for test and evaluation (T&E)of an Air Force weapon system are identified in detail in the Test Program Outline (TPO), which is prepared by the responsible Air Force T&E organization. In general, AFOTEC is that test organization for major programs (those requiring Defense Acquisition Board (DAB) or AFSARC review), while a Service Major Command test agency would conduct the test for non-major programs, with AFOTEC monitoring and providing assistance, as required.

During the advanced planning phase of a weapon system acquisition (5-6 years prior to OT&E), AFOTEC (TE/XP) prepares the OT&E section of the first full TPO, coordinates the TPO with all supporting organizations, and assists the resource manager (AFOTEC/RM) in programming of required resources. The resource requirements listed in the TPO are developed by the resource manager, test manager, and Operational Test Director using sources such as the statement of operational need (SON) and threat assessments. The TPO should specify in detail all the resources necessary to successfully conduct a test.

The TPO is the formal means by which test resource requirements are communicated to the Air Staff and to the appropriate commands and agencies tasked to supply the needed resources. Hence, if a required resource is not specified in the TPO, it is likely that the resource will not be available for the test. The TPO is revised and updated every six months , since the test resource requirements become better defined as the OT&E plans mature. The initial TPO serves as a baseline for comparison of planned OT&E resources with actual expenditures. Comparisons of the initial TPO with subsequent updates provides an audit trail of changes in the test program and its testing requirements. AFOTEC maintains all TPOs on a computer data base, which permits immediate response to all queries regarding test resource requirements.

AFOTEC/RM consolidates the resource requirements from all TPOs, both AFOTEC and MAJCOM prepared, with participating and supporting organizations and agencies outside AFOTEC. Twice yearly, the RM office prepares a draft of the USAF Program for OT&E (the Program Outline (PO)), which is a master planning and programming document for resource requirements for all HQ USAF-directed OT&E, and distributes it to all concerned commands, agencies, and organizations for review and coordination. The PO is then submitted to the Air Staff for review and approval by the Operational Resource Management Assessment System for Test and Evaluation (ORMAS/TE), which operates under the authority of HQ AF/XOORE. The ORMAS Board is composed of HQ USAF action officers and senior officers from MAJCOMs and agencies involved in OT&E; it meets semiannually to review the PO, identify the impacts of OT&E resource requests on operational command mission requirements, and resolve such impacts and conflicting requirements at the appropriate Air Staff level. Through the ORMAS process, HQ USAF approves the PO, and it becomes directive to all participants to take planning, programming, and budgeting actions. Agreements made among ORMAS participants regarding TPO and PO resource requirements are considered binding.

All requests for test resources are coordinated by HQ AFOTEC as part of the TPO preparation process. When a new weapon system development is first identified, AFOTEC provides a Test Manager (TM) who begins long term OT&E planning. The TM begins identifying needed test resources, such as instrumentation, simulators, and models, and works with the AFOTEC/RM directorate to obtain them. If the required resource does not belong to AFOTEC, AFOTEC/RM will negotiate with the commands having the resource. In the case of models and simulators, AFOTEC surveys what is available, assesses credibility, then coordinates with the owner or developer to use it. The Joint Technical Coordinating Group publishes a document on EW models.

Range scheduling should be done as early as possible. At least a year is required, but often a test can be accommodated with a few months notice if there is no requirement for special equipment or modifications to be provided at the range. Some of the Air Force ranges are scheduled well in advance and cannot accommodate tests which encounter delays or retest requirements.

AFOTEC/RM attempts to resolve conflicts among various systems competing for scarce test resources and can elevate the request to the Commander, AFOTEC if necessary. Decisions on resource utilization and scheduling are based on the weapon system's assigned priority.

AFOTEC/RM and the Test Manager also arrange for use of the resources of other Services, non-DoD government agencies, and contractors. Use of non-U.S. resources, such as a Canadian range, are coordinated by AF/XOORE and based on formal Memoranda of Understanding (MOU). USAFE/DOQ handles requests for European ranges. Use of a contractor-owned resource, such as a model, is often obtained through the System Program Office (SPO) or a General Support Contract.

18.4 TEST RESOURCE FUNDING

The Five Year Defense Program (FYDP) is the basic DoD programming document that records, summarizes, and displays Secretary of Defense (SECDEF) decisions. In the FYDP, costs are divided into three categories for each program element: research and development costs, investment costs, and operating costs. Congress appropriates to the Office of Management and Budget (OMB) who apportions funding through the SECDEF to the Services and to other Defense Agencies who allocate funds to others (claimants, sub-claimants, administering offices, commanding generals, etc.).

The Planning, Programming, and Budgeting System (PPBS) is a DoD internal system that is used to develop the inputs to Congress for each year's budget while developing future year budgets. The PPBS is milestone oriented. There are four concurrent PPBS cycles ongoing at one time. These cycles are: planning, programming, budgeting, and execution/enactment. At any one time there are three budgets being worked by the Services. The current fiscal year budget is being executed, the following year's budget is being programmed, and the next year's budget is being planned.

There are six types of funding in the PPBS: Research funding for maintaining the technology base; Exploratory Development funding for conducting the Concept Exploration/Definition phase; Advanced Development funding for conducting both the Concept Exploration/Definition phase and the Demonstration/Validation phase; Engineering Development funding for conducting the Full-Scale Development phase; Operational Systems Development funding for conducting the Production and Deployment phase; and Research, Development, Test and Evaluation (RDT&E) management and support funding which is used throughout the development and production cycle until the system is operationally deployed, where Operations and Maintenance (O&M) funding is used. The RDT&E appropriation funds the costs associated with research and development, including test items, DT&E and test support of OT&E of the system or equipment and the test items.

The funding that is planned, programmed, and budgeted through the PPBS cycle is not always the same funding amount that Congress appropriates or the Program Manager (PM) receives. If the required funding for a test program is not authorized by Congress, the Program Manager has four choices of how to react. The PM can submit a supplemental budget (for unfunded portions of his program), request deficiency funding (for unforeseen program problems), use transfer authority (from other programs within his Service), or he can reprogram the funds (to restructure his program).

Generally, testing accomplished for a specific system prior to the production decision is funded from Research, Development, Test and Evaluation (RDT&E) appropriations, while testing accomplished after the production decision is funded from other procurements, operations and maintenance (O&M) appropriations. Testing of product improvements, block upgrades, and major modifications is funded from the same appropriations as the program development. Follow-on Test and Evaluations (FOT&E) are normally funded from O&M funds.

Funding associated with T&E (including instrumentation, targets and simulations) are identified in the system acquisition cost estimates, Service acquisition plans, and the TEMP. General funding information for development and operational tests are as follows:

Development Test Funding. Funds required to conduct engineering and development tests are programmed and budgeted by the material developer, based upon the requirements of the TEMP. These costs may include, but are not limited to, procuring test sampler/prototypes, support equipment, transportation costs, technical data, training of test personnel, repair parts, and test specific instrumentation, equipment and facilities.

Operational Test Funding. Funds required to conduct OT are programmed and budgeted by the Service operational test agency or organization. The funds are programmed in the Service's long range test program, and the funds requirements are obtained from the test resourcing documentation and TEMP.

The Program Manager must pay for the use of all test resources, such as the MRTFB, and for the development of specialized resources needed specifically for testing the weapon system being developed.

18.4.1 Army Funding

Test resources are developed and funded under various Army appropriations. The Army Materiel Command and its commodity commands provide test items, spare parts, support items such as diagnostic equipment, and ammunition. Soldiers, ranges, fuel, test support personnel, and maneuver areas are provided by TRADOC or FORSCOM. The weapon system program manager uses RDT&E funds to reimburse these supporting commands for costs directly related to his test. The weapon system material developer is also responsible for funding the development of new test resources specifically needed to test the weapon system. Examples of such special purpose resources include models, simulations, special instrumentation and test equipment, range modifications, EW simulators, and sometimes threat simulators. Although the Army has a separate budget and development plan for threat simulators, the Army Development and Acquisition of Threat Simulators (ADATS) program, many weapon system developers still have to fund the cost of new threat systems that are specifically needed to test their weapon system.

18.4.2 Navy Funding

In the Navy, the weapon system PM is responsible for funding the development of all required test-specific resources, such as test articles, expendables, one-of-a-kind targets, data collection/reduction, and instrumentation, out of the program's RDT&E funds. The development of generic test resources, such as targets, threat simulators, and range capabilities, that can be used in OT&E of multiple weapons systems, is funded from OPNAV generic accounts (such as target development) and not from weapon system RDT&E. The PM's RDT&E funds pay for all DT and OT through OPEVAL. The PM pays for all post production OT with program funds.

18.4.3 Air Force Funding

In the Air Force, direct cost funding requires that test-peculiar (direct) costs associated with a particular test program be reimbursed by the System Program Office to the designated test agency. The RDT&E

appropriation funds the cost associated with research and development, including test items, DT&E and Air Force Systems Command (AFSC) support of OT&E of the system or equipment and the tests items. Costs associated with IOT&E are RDT&E funded and costs of QOT&E are Production funded. The IOT&E Manager prepares a Test Plan Outline (TPO) that summarizes the resource requirements for IOT&E and related test support. All pretest IOT&E planning is budgeted through and paid out of the operation account of AFOTEC or MAJCOM responsible for operating the system and funded by the O&M appropriation. The actual IOT&E is budgeted through and paid out of the RDT&E appropriation and directed to AFOTEC by HQ AFSC. FOT&E costs are paid by AFOTEC and/or the MAJCOM operating the system and funded by the O&M appropriation.

18.5 SUMMARY

Test resources are in great demand and their use must be scheduled well in advance of a test. Resources specific to a particular test must often be developed and funded from the PM's own RDT&E budget. Thus, the PM and his testers must ensure that test resource requirements are identified early in the acquisition cycle, that they are documented in the initial TEMP, and that modifications and refinements are reported in the annual TEMP updates.

Funds for testing are provided by Congressional appropriation to the OMB who apportions the funds to the to the Services through the SECDEF. The PPBS is the DoD process used to formulate budget requests to Congress. The Program Managers requests for test resources are usually outlined in the TEMP. Generally, System development is funded from RDT&E funds until the system is operationally deployed and maintained. The O&M funds are used for FOT&E and system maintenance. The weapon system material developer is also responsible for funding the development of new test resources specifically needed to test the weapon system.

CHAPTER 19

TESTING FOR VULNERABILITY AND LETHALITY

19.1 INTRODUCTION

This chapter addresses the need to explore the vulnerability and lethality aspects of a system through test and evaluation practices and procedures. In particular, this chapter describes the recently mandated Live Fire Test Program which has been established to evaluate the vulnerability and lethality of developing systems. It also discusses the role of test and evaluation in assessing a system's ability to perform in a nuclear combat environment. The discussion of testing for nuclear survivability is based primarily on information contained in the "Nuclear Survivability Handbook for OT&E," prepared by the Air Force Operational Test and Evaluation Center (Reference 91).

19.2 LIVE FIRE TESTING

19.2.1 Background

The National Defense Authorization Act for Fiscal Year 1987 (Reference 97) established a formal requirement for vulnerability and lethality testing. Specifically, this law requires that:

> (1) a major system "may not proceed beyond low-rate initial production until realistic survivability testing of the system is completed. . ." and
>
> (2) "a major munitions program or missile program may not proceed beyond low-rate initial production until realistic lethality testing of the program is completed. . ."

An amendment to this law has been proposed that will substitute the word "vulnerability" for "survivability". This will bring the legislation in closer alignment with DoD definitions of these two terms. Survivability is a broad concept that involves consideration of other factors such as susceptibility to hostile attack. Vulnerability (from a defensive point of view) or lethality (from an offensive point of view) refer to a measure of the probability of a kill, given a hit (Reference 37). Table 19-1 summarizes the relationships between the concepts of survivability, effectiveness, vulnerability, lethality, and susceptibility.

Guidelines in the legislation further stipulate that survivability and lethality tests must be conducted "sufficiently early

Table 19-1. Relationships Between Key Concepts

TERMINOLOGY	PERSPECTIVE DEFENSIVE	PERSPECTIVE OFFENSIVE	MEANING
SURVIVABILITY	X		PROBABILITY OF ENGAGEMENT
EFFECTIVENESS		X	
VULNERABILITY	X		PROBABILITY OF KILL GIVEN A HIT
LETHALITY		X	
SUSCEPTIBILITY	X		PROBABILITY OF ENGAGEMENT

Source: Adapted from "Live Fire Testing: Evaluating DoD's Programs," U.S. General Accounting Office, GAO/PEMD-87-17, August 1987, page 15.

in the development phase of the system or program to allow any design deficiency demonstrated by the testing to be corrected . . . before proceeding beyond low-rate initial production."

The legislation contains the following definitions of survivability and lethality testing:

> (1) Survivability testing means "testing for vulnerability and survivability of the system in combat by firing munitions likely to be encountered in combat. . .at the system configured for combat, with the primary emphasis on testing vulnerability with respect to potential user casualties. . ."
>
> (2) Lethality testing means "testing for lethality by firing the munition or missile concerned at appropriate targets configured for combat."

In these definitions the term "configured for combat" is understood to mean a weapon system, platform, or vehicle that is equipped with all dangerous materials, including all flammables and explosives, that would normally be on board in combat.

The Live Fire Test Program is an outgrowth of the OSD Joint Live Fire Test Program. The fundamental difference in the two programs is that the Live Fire Test Program has been established to examine systems that are still in development while the Joint Live Fire Program tests systems that are already in field use.

The Live Fire Test Program is administered by the Deputy Director Defense Research and Engineering(Test and Evaluation) (DDDR&E(T&E)). His responsibilities with regard to the Live Fire Test Program are listed in Table 19-2. Each of the Services has identified a focal point for Live Fire Testing. By September 1987, discussions between OSD and the Services had resulted in the identification of a total of 44 weapons systems for live fire testing.

19.2.2 Live Fire Tests

There are varying types and degrees of live fire tests. The matrix in Table 19-3 illustrates the various possible combinations. Of them, full-scale, full-up testing is usually considered to be the most realistic and is the type of testing called for in the National Defense Authorization for Act FY87.

The importance of full-scale testing has been well demonstrated by the recent Joint Live Fire tests. In one case, these tests contradicted

Table 19-2. Live Fire Test Responsibilities of the DDDRE(T&E)

- Implement all aspects of the Live Fire Test (LFT) Program
- Develop and recommend LFT policy
- Ensure Service LFT programs are realistic and relevant
- Evaluate LFT plans prepared by Services
- Direct/participate in making independent assessments of Service Live Fire Tests and Evaluations
- Improve the conduct of LFT programs
- Develop instrumentation and facilities for LFT
- Acquire foreign targets and ammunition

Source: Statement by the Assistant Deputy Under Secretary of Defense (Live Fire Test) Before the Acquisition Policy Panel of the House Armed Services Committee, September 10, 1987.

Table 19-3. Types of Live Fire Testing

Scale	Loading: Full-up	Loading: Inert[a]
Full Scale	Complete System: with combustibles (e.g., Bradley Phase II tests, aircraft "proof" tests)	Complete system: no combustibles (e.g., tests of new armor on actual tanks, aircraft flight control tests)
Sub-scale	Components, subcomponents: with combustibles (e.g., fuel cell tests behind armor mock-up aircraft engine fire tests)	Components, subcomponents, structures, terminal ballistics, munitions performance, behind-armor tests, warhead characterization (e.g., armor/ warhead interaction tests, aircraft component structural tests)

[a] In some cases, targets are "semi-inert" meaning some combustibles are on board but not all (Example: tests of complete tanks with fuel and hydraulic fluid, but dummy ammunition.)

Source: "Live Fire Testing: Evaluating DoD's Programs," General Accounting Office, GAO/PEMD-87-17, August 1987 earlier conclusions concerning the flammability of a new hydraulic fluid used in F-15 and F-16 aircraft. Laboratory tests had demonstrated that the new fluid was less flammable than the standard fluid. However, during the JLF tests, 30 percent of the shots on the new fluid resulted in fires contrasted with 15 percent of the shots on the standard fluid (Reference 100).

While much insight and valuable wisdom is to be obtained through the testing of components or subsystems, some phenomena are only observable when full-up systems are tested. The interaction of such phenomena has been termed "cascading damage." Such damage is a result of the synergistic damage mechanisms that are at work in the "real world" and likely to be found during actual combat. Live Fire Testing provides a means for examining the damages inflicted not only on materiel but also on personnel. The crew casualty problem is an important issue that the LFT program is addressing. The program provides an opportunity to assess the effects of the complex environments that crews are likely to encounter in combat (e.g., fire, toxic fumes, blunt injury shock, and acoustic injuries) (Reference 91).

19.2.3 Use of Modeling and Simulation

Survivability and lethality assessments have traditionally relied to a great extent on the use of modeling and simulation techniques. The Live Fire Test Program does not replace the need for such techniques; in fact, the Live Fire Test Guidelines issued by OSD in May 1987 require that no shots be conducted until pre-shot model predictions are made concerning the expected damage. Such predictions are useful for several reasons. First, they assist in the test planning process. If a model predicts that no damage will be inflicted, test designers and planners should re-examine the selection of the shotlines and/or re-assess the accuracy of the threat representation. Second, pre-shot model predictions provide the Services with the opportunity to validate the accuracy of the models by comparing them with actual LFT results. At the same time, the LFT program reveals areas of damage that may be totally absent from existing models and simulations. Third, pre-shot model predictions can be used to help conserve scarce target resources. For example, models can be used to determine a sequence of shots that provides for the less damaging shots to be conducted first, followed by the more catastrophic shots resulting in maximum target damage.

19.2.4 Live Fire Test Guidelines

Live Fire Test Guidelines were issued in May 1987 by OSD in support of DoD 5000.3-M-1, "Test and Evaluation Master Plan (TEMP) Guidelines." Although not formally approved, the guidelines state that plans for live fire testing must now be included in the TEMP. Key points covered in the LFT Guidelines include the following:

- The Live Fire Test and Evaluation (LFT&E) plan is the basic planning document used by OSD and the Services to plan, review, and approve LFT&E.

- The LFT&E plan must contain general information on the system's required performance, operational and technical characteristics, critical test objectives, and the evaluation process.

- Each LFT&E plan must include testing of complete systems. A limited set of live fire tests may involve production components configured as a subsystem prior to full-up testing.

- A Service report must be submitted within 30 days of the completion of the live fire test. The report must include the firing results, test conditions, limitations, and conclusions and be submitted in both classified and unclassified form.

- A separate test report will be produced by OSD. The conclusions of the OSD report will be independent of, and uncoordinated with, the conclusions of the Service report.

- Congress shall have access to all live fire test data and all live fire test reports held by or produced by the Secretary of the Service concerned or by OSD.

- The costs of all live fire tests shall be paid from funding for the system being tested. In some instances, the DDDR&E (LFT) may elect to supplement such funds for the acquisition of targets or target simulators, although the ultimate responsibility rests on the Service concerned.

19.3 TESTING FOR NUCLEAR HARDNESS AND SURVIVABILITY

19.3.1 Background

Nuclear survivability must be incorporated into the design, acquisition, and operation of all systems that must perform critical missions in a nuclear environment. Nuclear survivability is achieved through a combination of four methods: hardness, avoidance, proliferation, and reconstitution. Hardness allows a system to physically withstand a nuclear attack. Avoidance encompasses the measures taken to not encounter a nuclear environment. Proliferation involves having sufficient numbers of a system to compensate for probable losses. Reconstitution includes the actions taken to repair or resupply damaged units in time to complete a mission satisfactorily.

There is a wide variety of possible effects from a nuclear detonation. They include: electromagnetic pulse (EMP), ionizing radiation, thermal radiation, blast, shock, dust, debris, blackout, and scintillation. Each weapon system is susceptible to some, but not all, of these effects. The Program Manager and his staff must identify the effects that may have an impact on the system under development and manage the design, development, and testing of the system in a manner that minimizes degradation. The variety of possible nuclear effects is described more fully in the "Nuclear Survivability Handbook for Air Force OT&E" (Reference91).

19.3.2 Assessing Nuclear Survivability Throughout The System Acquisition Cycle

The Program Manager must ensure that nuclear survivability issues are addressed throughout the system acquisition cycle. During the Concept Exploration/Definition Phase, the survivability requirements stated in the various Service requirements documents (e.g., Required Operational Capability (ROC), Statement of Operational Need (SON), or Operational Requirement (OR)) should be verified, refined, or further defined. During the Concept Demonstration and Validation Phase, trade-offs between hardness levels and other system characteristics (such as weight, speed, range, cost and operational effectiveness) should be described quantitatively. Trade-offs between hardness, avoidance, proliferation, and reconstitution as methods for achieving survivability should also be considered at this time. During the Full-Scale Development Phase, the system must be adequately tested to confirm that hardness objectives, criteria, requirements, and specifications are met. Plans for nuclear hardness and survivability testing must be outlined in the Test and Evaluation Master Plan. The appropriate commands must make provision for test and hardness surveillance equipment and procedures so that required hardness levels can be maintained once the system is operational.

During the Production Phase, system hardness is maintained through an active hardness assurance program. Such a program ensures that the end product conforms to hardness design specifications and that hardness aspects are re-evaluated before any retrofit changes are made to existing systems.

Once a system is operational, a hardness surveillance program may be implemented to maintain system hardness and to identify any further evaluation, testing, or retrofit changes required to ensure survivability. A hardness surveillance program consists of a set of scheduled tests and inspections to ensure that a system's designed hardness is not degraded through operational use, logistic support, maintenance actions, or natural causes.

19.3.3 Test Planning

The "Nuclear Survivability Handbook for Air Force OT&E" describes the following challenges associated with nuclear hardness and survivability testing:

(1) The magnitude and range of effects from a nuclear burst are much greater than those from conventional explosions that may be used to simulate nuclear bursts. Nuclear detonations have effects not found in conventional explosions. The intense nuclear radiation, blast, shock, thermal, and EMP fields are difficult to simulate. In addition, systems are often tested at stress levels that are either lower than those established by the criteria or lower than the level needed to cause damage to the system.

(2) The yields and configurations for underground testing are limited. It is generally not possible to test all relevant effects simultaneously or to observe possibly important synergisms between effects.

(3) System-level testing for nuclear effects is normally expensive, takes years to plan and conduct, and requires specialized expertise. Often, classes of tests conducted early in the program are not repeated later. Therefore, operational requirements should be folded into these tests from the start, often early in the acquisition process. This mandates a more extensive combined DT&E/OT&E test program than normally found in other types of testing.

Program Managers and test managers must remain sensitive to the ambiguities involved in testing for nuclear survivability. For example, there is no universal quantitative measure of survivability, and statements of survivability may lend themselves to a variety of interpretations. Moreover, it can be difficult to combine system vulnerability estimates for various nuclear effects into an assessment of overall survivability. As a result, program/test managers must exercise caution when developing test objectives and specifying measures of merit related to nuclear survivability.

19.3.4 Test Execution

For nuclear hardness and survivability testing, DT and OT efforts are often combined because it is not possible to test in an actual operational nuclear environment. The use of an integrated DT/OT program requires early and continuous dialogue between the two test communities so that each understands the needs of the other and to obtain the maximum cooperation in meeting objectives.

Test and evaluation techniques available to validate the nuclear survivability aspects of systems and subsystems include underground nuclear testing, environmental simulation (system-level, subsystem level, and component level), and analytical simulation. Table 19-4 outlines the major activities relevant to the assessment of nuclear hardness and survivability and the phases of the acquisition cycle in which they occur.

19.4 SUMMARY

The vulnerability and lethality aspects of a system can be evaluated through live fire tests. These tests are used to provide an insight into the system's ability to protect its crew and to continue to operate/fight after being hit by enemy weapons. It provides a means for examining the damages inflicted, not only on material, but also on personnel. Live fire testing also provides an opportunity to assess the effects of complex environments that crews are likely to encounter in combat.

Nuclear survivability must be carefully evaluated during the system acquisition cycle. Trade-offs between hardness levels and other system characteristics, such as weight, speed, range, cost, etc., must be evaluated. Nuclear survivability testing is difficult, and the evaluation of test results may lend themselves to a variety of interpretations. Therefore, Program Managers must exercise caution when developing test objectives related to nuclear survivability.

Table 19-4. Nuclear Hardness and Survivability Assessment Activities

CONCEPT EXPLORATION/DEFINITION PHASE

- Preparation of Test and Evaluation Master Plan (TEMP) that includes initial plans for nuclear hardness and survivability (NH&S) tests
  - Identification of NH&S requirements in verifiable terms
  - Identification of special NH&S test facility requirements with emphasis on long-lead-time items

- Development of nuclear criteria

CONCEPT DEMONSTRATION/VALIDATION PHASE

- Increased test planning

- TEMP update

- Conduct of NH&S trade s udies
  - NH&S requirements versus other system requirements
  - Alternate methods for achieving NH&S

- Conduct of limited testing
  - Piece-part hardness testing
  - Design concept trade-off testing
  - Technology demonstration testing

- Development of system specifications that include quantitative hardness levels

Table 19-4. Nuclear Hardness and Survivability Assessment Activities (Concluded)

FULL-SCALE DEVELOPMENT PHASE

- First opportunity to test prototype hardware
- TEMP update
- Development of Nuclear Hardness Design Handbook
  - Prior to Preliminary Design Review
  - Usually prepared by nuclear effects specialty contractor
- Conduct of testing
  - Pre-Critical Design Review (CDR) development and qualification tests
  - Development testing on nuclear-hardened piece parts, materials, cabling, and circuits
  - NH&S box and subsystem qualification tests (post-CDR)
  - Acceptance tests to verify that hardware meets specifications (post-CDR, prior to first delivery)
  - System-level hardness analysis (using box and subsystem test results)
  - System-level NH&S test

PRODUCTION AND DEPLOYMENT PHASE

- Implementation of program to ensure system retains its NH&S properties throughout production and deployment
- Screening of production hardware for hardness

OPERATIONAL SUPPORT PHASE

- Implementation by user of procedures to ensure that system's operation, logistic support and maintenance do not degrade hardness features
- Reassessment of survivability throughtout system life cycle

CHAPTER 20

MULTISERVICE TESTS

20.1 INTRODUCTION

This chapter discusses the planning and management of a multiservice test program. A multiservice test program is conducted when a system is to be acquired for use by more than one Service, or when a system must interface with equipment of another Service. A multiservice test program should not be confused with the OSD-sponsored, non-acquisition-oriented Joint Test and Evaluation (JT&E) program. A brief description of the JT&E program is provided in Chapter 3.

20.2 BACKGROUND

DOD Directive 5000.3 contains a definition of multiservice test and evaluation, designates the participants in the program, and gives a Lead Service responsibility for preparing a single report concerning a system's operational effectiveness and suitability. (The Lead Service is the Service responsible for the overall management of a multiservice program. A "Supporting Service" is a Service designated to assist the Lead Service.)

A multiservice test and evaluation program may include either DT&E or OT&E or both. The Services Operational Test Agencies have executed a formal Memorandum of Agreement on multiservice OT&E (Reference 35) that provides a framework for the conduct of a multiservice operational test program.

Air Force Regulation 80-14 describes the procedures followed in a multiservice T&E program as follows:

> (1) In a multiservice acquisition program, T&E is planned and conducted according to Lead Service regulations. The designated Lead Service will have the overall responsibility for management of the multiservice program and will ensure that supporting service requirements are included. If another Service has certain unique T&E requirements, testing for these unique requirements may be planned, funded, and conducted according to that Service's regulations.
>
> (2) Participating Services will prepare reports in acccrdance with their respective regulations. The Lead Service will prepare and coordinate a single DT&E report and a single OT&E report, which will summarize the conclusions and recommendations of

each Service's reports. Rationale will be provided to explain any significant differences. The individual Service reports will be attached to this single report.

(3) Deviations from the Lead Service T&E regulations may be accommodated by mutual agreement among the Services involved.

20.3 TEST PROGRAM RESPONSIBILITIES

The Lead Service has overall management responsibility for the program. It must ensure that supporting Service requirements are included in the formulation of the basic resource and planning documents.

A Test Management Council (TMC) is established for each multiservice test program. Its membership consists of one senior representative from each participating Service or agency headquarters. The TMC works very closely with the PMO and is responsible for arbitrating all disagreements among Services that cannot be resolved at the working level.

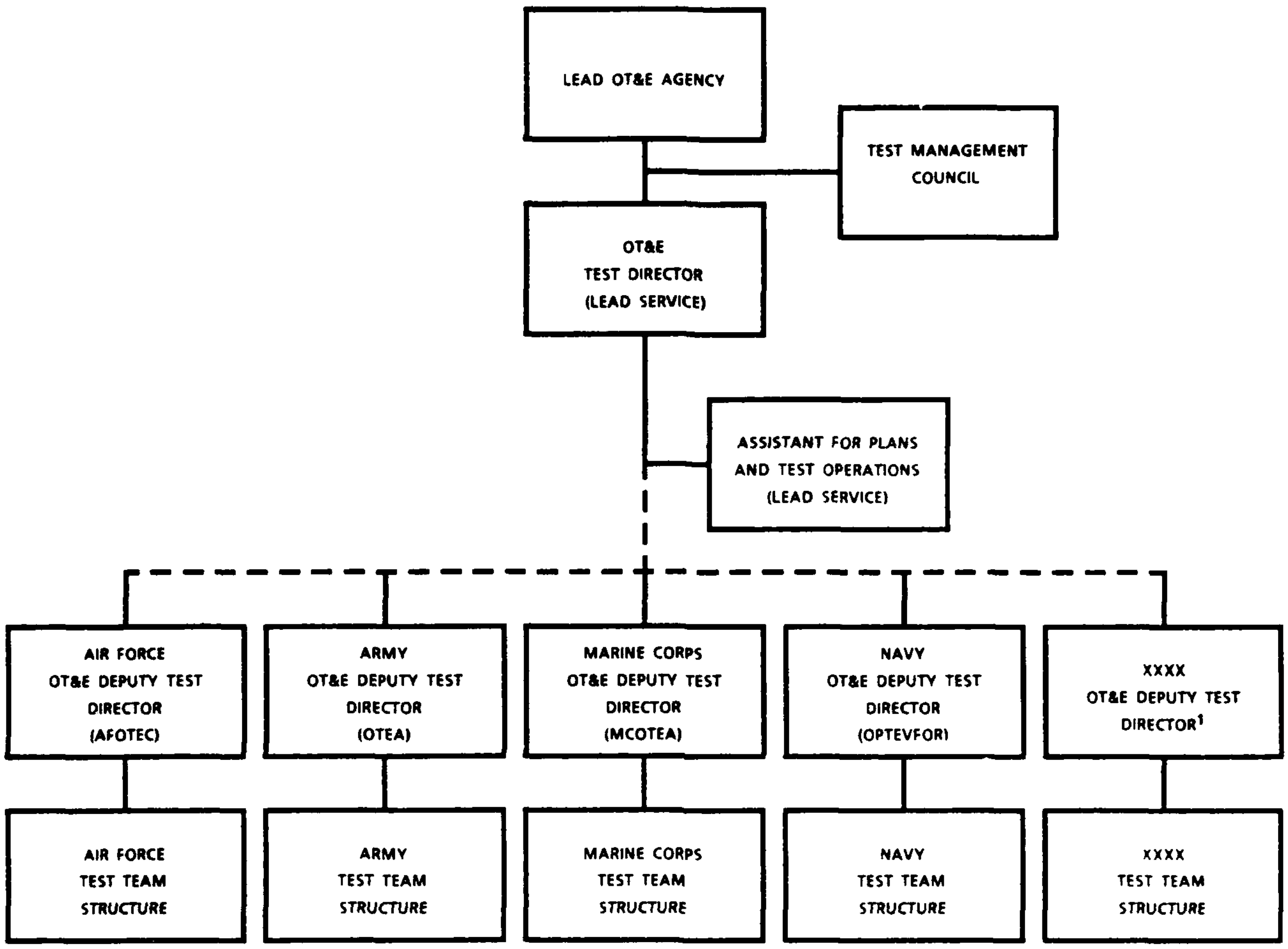
Resource requirements are documented in the Test and Evaluation Master Plan. Each participating Service is directed to budget for the testing necessary to accomplish its assigned test objectives and for the participation of its personnel and equipment in the entire test program.

20.4 TEST TEAM STRUCTURE

A sample test team structure is shown in Figure 20-1. As shown in the figure, Service test teams work through a Service Deputy Test Director, or senior representative. The Test Director exercises test management authority over the test teams, but not operational control. His responsibilities include integration of test requirements and efficient scheduling of test events. The Deputy Test Directors exercise operational control or test management authority over their Service test teams in accordance with their Service directives. Additionally, they act as advisors to the Test Director; represent their Service's interests; and are responsible, at least administratively, for resources and personnel provided by their Services.

20.5 TEST PLANNING

Test planning for multiservice T&E is accomplished in the manner prescribed by Lead Service directions and in accordance with the following general procedures extracted from the "Memorandum of Agreement on Multi-Service OT&E and Joint T&E":



*7-2-MCL2-000185-05

1. USED FOR COMPLEX PROGRAMS WITH MANY PARTICIPANTS

SOURCE: "MEMORANDUM OF AGREEMENT ON MULTI-SERVICE OT&E AND JOINT T&E"

Figure 20-1. Simple Multiservice OT&E Test Team Composition

(1) The Lead Service T&E agencies begin the planning process by issuing a call to the supporting Service T&E agencies for critical issues and test objectives.

(2) The Lead Service T&E agencies consolidates the objectives into a list and coordinates the list with the supporting Service T&E agencies.

(3) The Lead Service T&E agency accommodates supporting Service T&E requirements and inputs in the formal coordination action of the TEMP.

(4) Participating T&E agency project officers assign responsibility for the accomplishment of test objectives (from the consolidated list) to each T&E agency. These assignments are made in a mutually agreeable manner. Each agency is then responsible for resource identification and accomplishment of its assigned test objectives under the direction of the Lead Service T&E agency.

(5) Each participating agency prepares the portion of the overall test plan(s) for its assigned objectives, in the Lead Service's test plan(s) format, and identifies its data needs.

(6) The Lead Service's T&E agency prepares the multiservice T&E test plan(s), consolidating the inputs from all participating agencies.

20.6 DISCREPANCY REPORTING

In a multiservice T&E program, a discrepancy report is a report of any condition which reflects adversely on the item being tested and which must be reported outside the test team for corrective action. The discrepancy reporting system of the Lead Service is normally used. All members of the multiservice test team will report discrepancies through their Service's system.

Items undergoing test will not necessarily be used by each of the Services for identical purposes. As a result, a discrepancy considered disqualifying by one Service is not necessarily disqualifying for all of the Services. Discrepancy reports of a disqualifying nature must include a statement by the concerned Service of why the discrepancy has been so classified. It also includes statements by the other Services as to whether or not the discrepancy significantly affects them.

In the event that one of the participating Services identifies a discrepancy that it considers warrants termination of the test, the circumstances are reported immediately to the Test Director.

20.7 TEST REPORTING

The following test reporting policy applies to multiservice OT&E programs:

(1) Interim test reports are not normally prepared. If they are required on a particular program, they are prepared in accordance with Lead Service's directives and coordinated with all participating OT&E agencies prior to release.

(2) Within 60 days of the end of testing, the multiservice OT&E team must present a factual report of the test to all participating OT&E agencies. (This factual report presents the data collected, but no evaluation, conclusions, or recommendations concerning the data.)

(3) Each participating OT&E agency prepares an independent evaluation report in its own format and forwards that report through its normal Service channels.

(4) Approved independent evaluation reports are distributed to all participating OT&E agencies.

(5) The Lead Service OT&E agency is responsible for preparing the Defense Acquisition Board (DAB) briefing(s) which is (are) coordinated with all participating OT&E agencies.

20.8 SUMMARY

Multiservice test programs are conducted by two or more Services when a system is to be acquired by more than one Service or when a system must interface with equipment of another Service. Test procedures for multiservice test and evaluation follow those of the designated Lead Service with mutual agreements resolving areas where deviations are necessary. Care must be exercised when integrating test results and reporting discrepancies since items undergoing test may be used for different purposes in different Services. Close coordination is required to ensure that an accurate summary of the developing system's capabilities is provided to Service and DoD decision authorities.

CHAPTER 21

INTERNATIONAL TEST AND EVALUATION PROGRAMS

21.1 INTRODUCTION

This chapter discusses test and evaluation from an international perspective. It describes the OSD-sponsored Foreign Weapons Evaluation (FWE) and NATO Comparative Test Programs and discusses factors that bear on the test and evaluation of multinational acquisition programs.

21.2 FOREIGN WEAPONS EVALUATION PROGRAM

21.2.1 Program Objective

The Foreign Weapons Evaluation Program is designed to support the evaluation of a foreign nation's weapons system, equipment, or technology in terms of its potential to meet a valid requirement of one or more of the U.S. Armed Services. Additional goals of the FWE program include avoiding unnecessary duplication in development, enhancing standardization and interoperability, and promoting international technology exchanges. The FWE program is not intended for use in exploiting threat systems or for intelligence gathering purposes. The primary objective of the program is to reduce the costs of research and development, while leading to the acquisition of foreign equipment for U.S. use. Policy and procedures for the execution of the FWE program are documented in DoD 5000.3-M-2.

21.2.2 Program Administration

Foreign weapons evaluation activities and responsibilities are assigned to the Director Defense Test and Evaluation (now Deputy Director Defense Research and Engineering (Test and Evaluation) (DDDR&E(T&E)) by direction of the Congress in 1980. Each year, sponsoring military services forward to the DDDR&E(T&E) Candidate Nomination Proposals (CNPs) for systems to be evaluated under the FWE program. The services are encouraged to prepare and submit a CNP whenever a promising candidate is found that appears to satisfy a current or potential service requirement. A CNP must contain the information as required by DoD 5000.3-M-2.

The fundamental criterion for FWE program selection is the candidate system's potential to satisfy an existing or projected operational or training requirement or its possible contribution to the U.S. technology base. Additional factors influencing candidate selection include the following: candidate maturity, available test data, multiservice interest, existence of a statement of operational requirement need, potential for subsequent procurement, sponsorship by U.S. based licensee, realistic evaluation schedule cost, DoD Component OSD evaluation cost sharing proposal and preprogrammed procurement funds. For technology evaluation programs, within the FWE program, the candidate nomination proposal must address the specific arrangements under which the U.S. and the foreign participants (governments, armed forces, corporations) will operate. These may include government-to-government Memoranda of Agreement, private industry licensing agreements, data exchange agreements and/or cooperative technology exchange programs.

Foreign weapons evaluation activities are funded by OSD and executed by the Service with the potential need for the system. Points of contact at the headquarters level in each of the Services monitor the conduct of the programs. Work is performed in laboratories and test centers throughout the country. Systems evaluated recently under the FWE program include millimeter wave communications equipment, chemical defense equipment, gunnery devices, maritime decoys, and navigational systems.

21.3 NATO COMPARATIVE TEST PROGRAM

The NATO Comparative Test Program is an expanded version of the FWE program. It was created by an act of Congress in the FY86 Defense Authorization Bill. The program supports the evaluation of NATO nations' weapons systems, equipment, and technology and assesses their suitability for use by U.S. forces. The selection criteria for the NATO Comparative Test Program are essentially the same as for the FWE program with the exception that the equipment must be produced by a NATO member nation and be considered as an alternative to a system either in the late stage of development in the US or offer a cost, schedule, or performance advantage over US equipment. In addition, the NATO Comparative Test Program requires that notification be sent to the Armed Services and Appropriations Committees of the House of Representatives and Senate before funds are obligated. With this exception, the NATO Comparative Test Program follows the same nomination process and administrative procedures as the Foreign Weapons Evaluation Program. Guidelines for the program will also be contained in DoD 5000.3-M-2.

Proposals recently funded under the NATO Comparative Test Program include test and evaluation of a German mine reconnaissance and detection system for the Army, a United Kingdom-designed minehunter for the Navy, and the Norwegian Penguin missile system for the Air Force. According to the FY88 Report of the Secretary of Defense to the Congress, the program has generated considerable interest among the NATO allied nations and has become a primary means of promoting armaments cooperation within NATO.

Problems associated with testing foreign weapons normally stem from politics, national pride, and a lack of previous test data. When foreign companies introduce weapon systems for test, they will often attempt to align the U.S. military/Congressional organizations with their systems. For example, when a foreign nation introduced an anti-tank weapon to the

Army, they did so by having a U.S. Senator write the Army stating a need for the system. The letter had attached a document containing doctrine to employ the system and a test concept for use when evaluating the system. Systems that are tested in the NATO Comparative Test Program often become involved in national pride. The test community must be careful not to allow national pride to be a driving force in the evaluation. The 9mm pistol competition in NATO, at times, took on the form of an international soccer match, with each competing nation cheering for their pistol and many other nations selecting sides. The evaluation of the 9mm pistol was difficult because of these forces. United States testers must make every effort to obtain all available test data on foreign systems. These data can be used to help validate the evolving test data and additional test data during the evaluation.

21.4 TEST AND EVALUATION MANAGEMENT IN MULTINATIONAL PROGRAMS

Rationalization, standardization, and interoperability have become increasingly important elements in the materiel acquisition process. Public Law 94-361, passed on July 14, 1976, requires that "equipment for use of personnel of the Armed Forces of the United States stationed in Europe under the terms of the North Atlantic Treaty should be standardized or at least interoperable with equipment of other members of the North Atlantic Treaty Organization" (Reference 4, pages 1-2). Program Managers and test managers must, therefore, be fully aware of any potential international applications of the systems for which they are responsible. The Joint Logistics Commanders Guide for the Management of Multinational Programs published by the Defense Systems Management College (Reference 47) is a valuable compendium of information for the Program Manager of a developing system with potential multinational applications.

Representatives of the United States, United Kingdom, France, and Germany have signed a Memorandum of Agreement concerning the mutual acceptability of each country's test and evaluation data. This agreement seeks to avoid redundant testing by documenting the extent of understanding between the governments involved concerning the mutual acceptability of their respective T&E procedures for those systems that are developed in one country and are candidates for procurement by one or more of the other countries. Focal points for both development and operational testing in each of the countries are identified, and procedures governing the generation and release of T&E data are described in the MOU.

Early and thorough planning is an important element of any successful test and evaluation program but is even more critical in a multinational program. Agreement must be reached concerning test and evaluation procedures, data requirements and methodology. Differences in tactics, battlefield representations, and military organizations may also make it difficult for one nation to accept another's test data. Therefore, agreement must be reached in advance concerning the operational test scenario and battlefield representation that will be used.

21.5 U.S. AND NATO ACQUISITION PROGRAMS

Some test programs involve combined development and test of new weapon systems for U.S. and other NATO countries. In these programs, some differences from the regular "way of doing things" occurs. For example, the formulation of the Request for Proposal (RFP) must be coordinated with the North Atlantic Program Management Agency (NAPMA) and their inputs to the statement of work, data requirements, operational test planning, and test schedule formulation must be included. Also, their operational user, Force Command must be involved in the operational test program. Usually, a Multinational Memorandum of Understanding (MMOU) is created concerning test program and production funding, test resources, test team composition, use of national assets for testing, etc. Nations are encouraged to use the data that another nation has gathered on similar test programs to avoid duplication of effort.

> For example, during the U.S. and NATO AWACS Electronic Support Measures (ESM) program, both U.S. and NATO E-3A's will be used for test aircraft in combined DT&E testing and the subsequent OT&E testing. Testing will be conducted in the U.S. and in the European threaters. The Joint Test Force will be composed of Program Management Office, contractor, U.S. operational users, AFOTEC, Force Command (NATO users) and logistics personnel for this program. A Multinational Memorandum of Agreement for this program was created. The U.S. program is managed by the AWACS System Program Office and the NATO program is managed by the North Atlantic Program Management Agency (NAPMA).

21.6 SUMMARY

The procurement of weapon systems for use by the US Armed Forces from foreign nations can provide the following advantages: reduced research and development costs; a faster initial operational capability; improved interoperability with friendly nations; and lower procurement costs because of economies of scale. The testing of such systems presents specific challenges in order to accommodate the needs of all users. Such testing requires careful advance planning and systematic execution. Expectations and understandings must be well documented at an early stage to ensure that the test results have utility for all concerned.

CHAPTER 22

T&E POLICY STRUCTURE AND OVERSIGHT MECHANISM

22.1 INTRODUCTION

This chapter provides an overview of the policy and organizations which govern the conduct of test and evaluation activities within the Department of Defense (DoD). It discusses Congressional legislation and activities for compliance by the DoD. It outlines the responsibilities of the DoD test organizations, at both the OSD and Service level, and describes related T&E policy.

22.2 THE CONGRESS

The Congress has shown a long-standing interest in influencing the DoD acquisition process. In the early seventies, in response to urging by Congress and recommendations by a Presidential Blue Ribbon Panel on Defense Management, the Deputy Secretary of Defense, David Packard, promulgated a package of policy initiatives which established the Defense Systems Acquisition Review Council (DSARC). The DSARC was organized to resolve acquisition issues, whenever possible, and to provide recommendations to the Secretary of Defense (SECDEF) on the acquisition of major weapon systems. Also as a result of the Congressional Directives, the Army and Air Force established independent operational test agencies. The Navy Operational Test and Evaluation Force came into being in the late sixties. In 1983, similar concerns led Congress to direct the establishment of the independent office of Director Operational Test and Evaluation (DOT&E) within the OSD. In 1985 a report released by the President's Blue Ribbon Commission on Defense Management, chaired by David Packard, made significant recommendations on the management and oversight of DoD's acquisition process and specifically test and evaluation. All of the Commission's recommendation have not been implemented and the full impact of these recommendations is not yet realized. In FY87 the Defense Authorization Act required live firing testing of weapon systems before the production phase begins.

The Department of Defense is required to provide to the Congress the following reports on test and evaluation:

- o Congressional Data Sheets (CDS). The CDS is an annual report on each major system acquisition. It must be updated before the contract is awarded and when procurement of the system is requested in the fiscal year. The CDS describes the DT&E and OT&E to be performed and the systems characteristics.

o Selected Acquisition Report (SAR). The SAR describes the system characteristics required and outlines significant progress and problems encountered. It lists tests completed and issues identified during testing.

o Annual System Operational Test Report. The Annual Systems Operational Test Report is provided by the DOT&E to the SECDEF and the Committees on Armed Services and Appropriations. The report provides a narrative and resource summary of OT&E and OT&E-related issues, activities, and assessments.

o Low Rate Initial Production Report (LRIP). Before proceeding beyond LRIP for each major system acquisition program, the Director, Operational Test & Evaluation must report to the SECDEF and Congress on the adequacy of OT&E and whether the T&E results confirm that the item or component actually tested are effective and suitable for combat.

22.3 OSD OVERSIGHT STRUCTURE

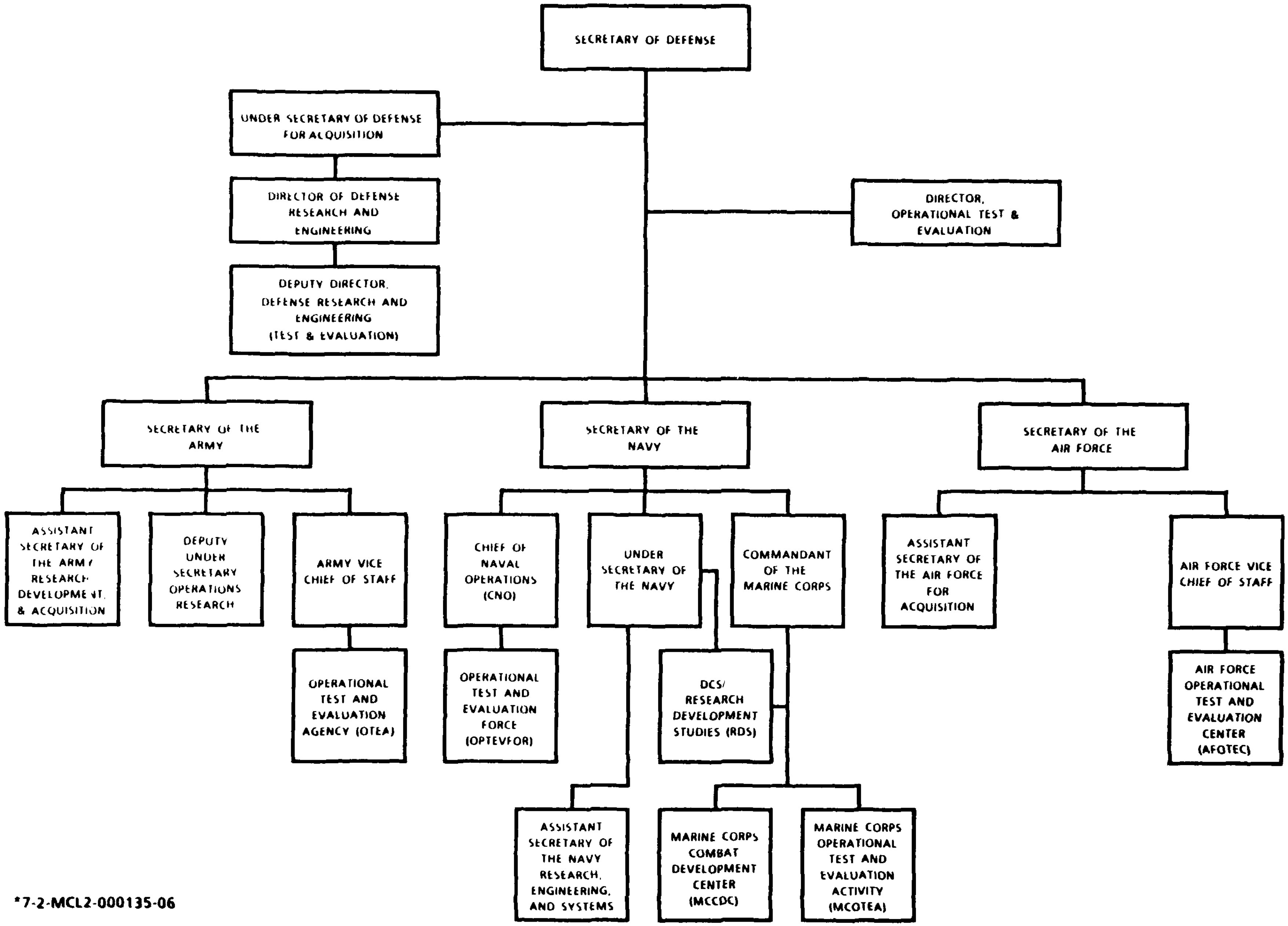
The organization of the Department of Defense for the oversight of test and evaluation is illustrated in Figure 22-1. The oversight of test and evaluation, in the Office of the Secretary of Defense (OSD), is performed by two primary offices: the Deputy Director, Defense Research and Engineering (Test and Evaluation) (DDDRE(T&E)), and the Director Operational Test and Evaluation (DOT&E). The management of acquisition programs in OSD is performed by the Defense Acquisition Executive (DAE) who uses the Defense Acquisition Board and ten committees to process information for decisions. The Under Secretary of Defense (Acquisition) (USD(A)) is the DAE and he uses the DAB and its committees to provide the senior level decision process for the acquisition of weapon systems.

22.3.1 Defense Acquisition Executive (DAE)

The Defense Acquisition Executive position was established in September 1986. He is the USD(A) and his responsibilities include "establishing policies for acquisition (including procurement, research and development, logisitics, development testing, and contracts administration) for all elements of the Department of Defense. His charter includes the authority over the Service and Defense Agencies on policy, procedure and execution of the acquisition process.

22.3.2 Defense Acquisition Board (DAB)

The DAB is the primary forum used by OSD to provide advice, assistance and recommendations, and to resolve issues regarding all operating and policy aspects of the DoD Acquisition System. The DAB is the senior management acquisition board chaired by the DAE and attended



*7-2-MCL2-000135-06

Figure 22-1. OSD Oversight of T&E

by the Vice Chairman of Joint Chiefs of Staff, Principal Under Secretary of Defense for Acquisition and the Services Acquisition Executives. As illustrated in Figure 22-2 the DAB conducts business through ten working committees. (DoDD 5000.49)

22.3.3 Test and Evaluation Committee (TEC)

The DAB committee that is responsible for T&E is the Test and Evaluation Committee. As illustrated in Figure 22-2, the TEC has the responsibility of DT&E, OT&E and test facilities. The TEC holds pre-DAB meetings for the purpose of resolving resourcing issues, developing recommendations and highlighting significant issues to be addressed by the DAB. The TEC is chaired by the DOT&E and has representation from DDDRE(T&E) and the Service Acquisition Executives.

22.3.4 Defense Resources Board (DRB)

The DRB was established by the SECDEF in 1979 to advise the SECDEF on policy, planning, program, and budget issues. The DRB is chaired by the Deputy Secretary of Defense and is responsible for the management and oversight of all aspects of the DoD planning, programming, and budgeting process. It oversees the annual budget review process and therefore has a major impact on test and evaluation resources. The DOT&E is a member of the DRB and can, therefore, have an impact on the resources for T&E.

22.3.5 Deputy Director Defense Research and Engineering (Test and Evaluation) (DDDRE(T&E))

The DDDRE(T&E) serves as the principal staff assistant and advisor to the Director Defense Research and Engineering for test and evaluation matters. He has authority and responsibility for all DT&E conducted on designated and major system Research & Engineering, Test and Evaluation programs. The DDDRE(T&E) organization is illustrated in Figure 22-3.

22.3.5.1 Duties of the DDDRE(T&E)

The DDDRE(T&E) performs the following duties within the acquisition community:

o Serves as the focal point for coordination of all Test and Evaluation Master Plans (TEMPs). Signs for approval of TEMPs with DOT&E.

o Reviews major defense acquisition program documentation for DT&E implications and resource requirements, to provide comments to the USD(A), DAE or DAB.

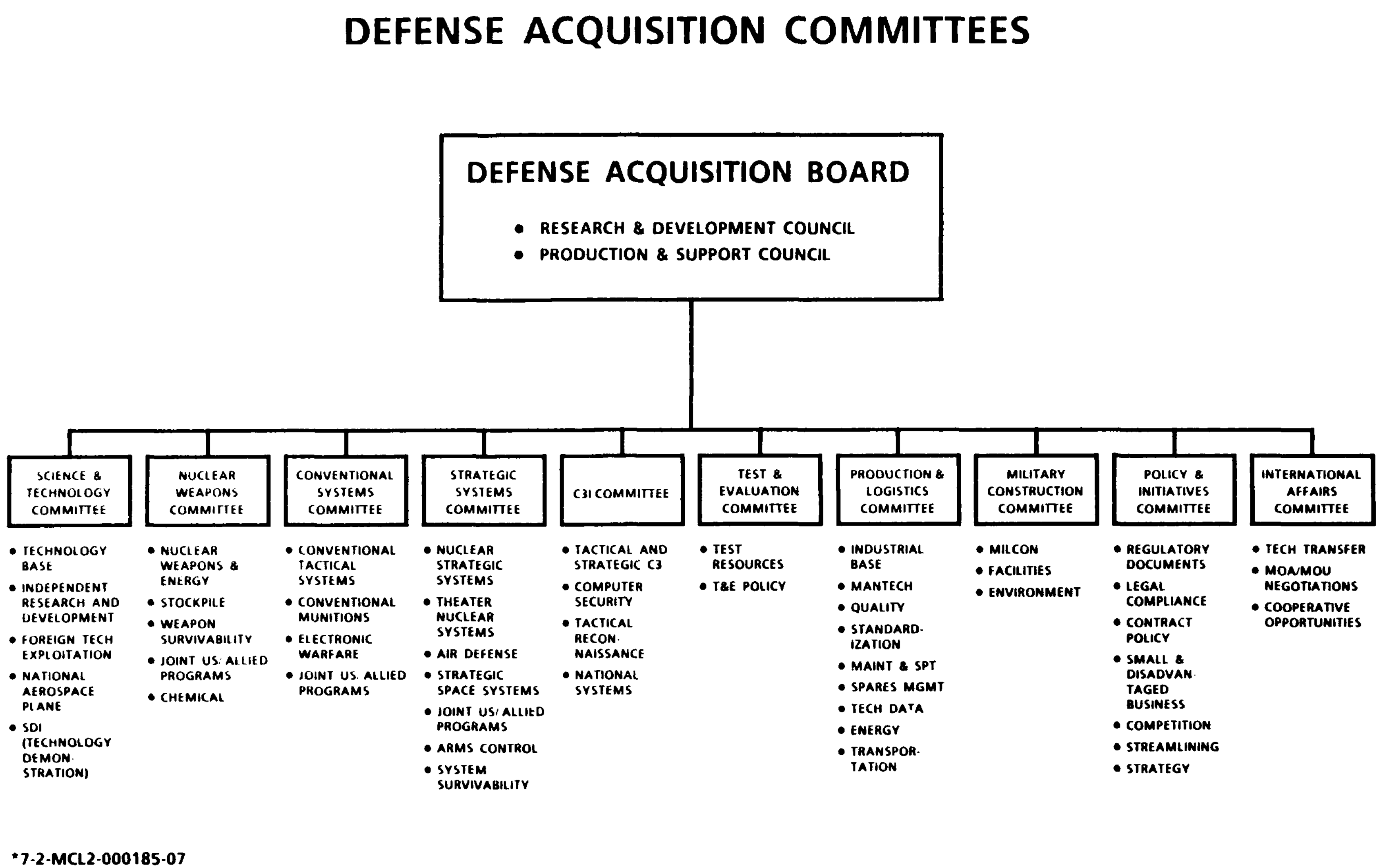


Figure 22-2. Defense Acquisition Committee Organization

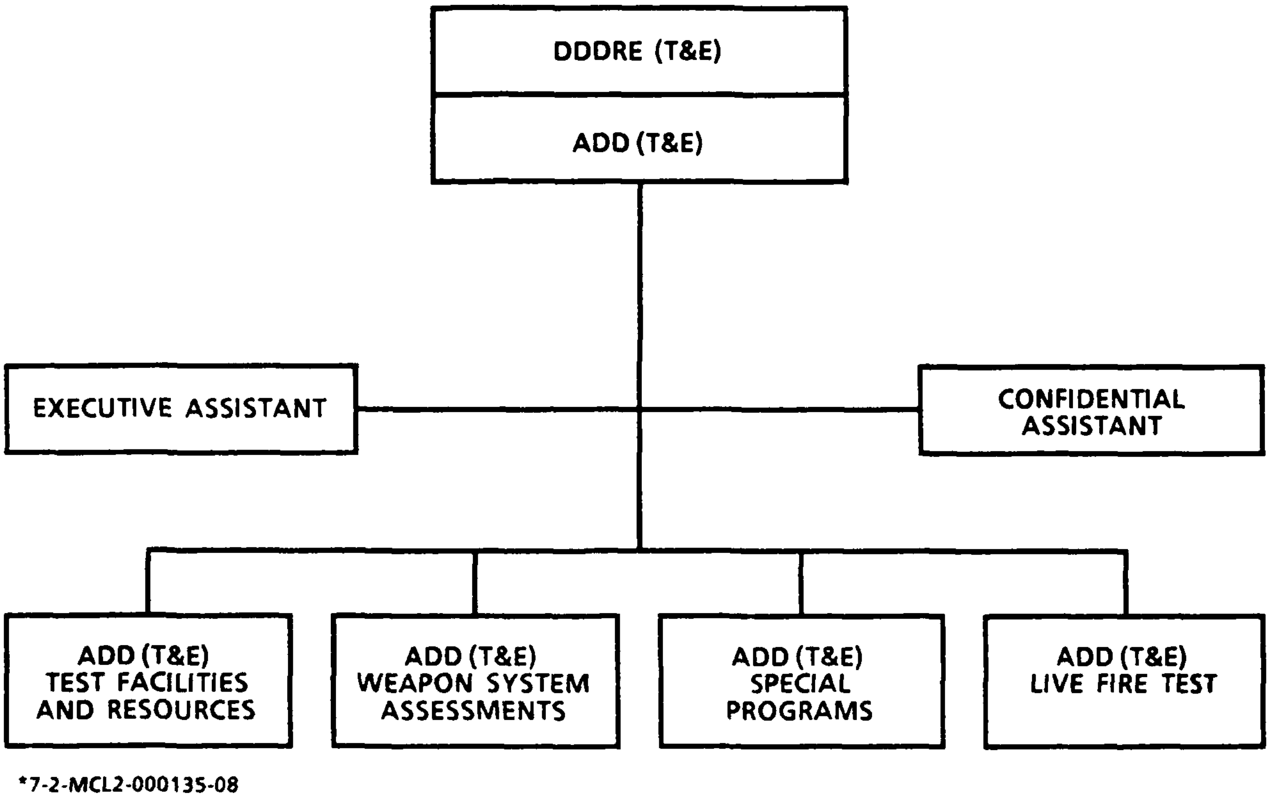


Figure 22-3. Office of the Deputy Director Defense Research and Engineering (Test & Evaluation)

o Observes DT&E to ensure adequacy of testing and to assess test results.

o Provides the DAE and DAB with a technical assessment of T&E conducted on a weapon system.

o Provides advice and makes recommendations to the SECDEF and issues guidance to the Service Acquisition Executives with respect to DT&E.

o Performs the administrative processing of nominations and charters for joint development test programs.

o Provides oversight of the Major Range and Test Facility Base.

o Administers the Foreign Weapons Evaluation Program and NATO Comparative Test Program.

o Confirms, with the advice from the Assistant to the Secretary of Defense (Atomic Energy), that nuclear survivability and hardness objectives have been addressed during DT&E.

22.3.5.2 DDDRE(T&E) and Service Reports

The DDDRE(T&E) and Services interaction during the testing of major and designated weapon systems includes the following reporting requirements.

o A TEMP (either initial or updated, as appropriate) must be provided for consideration and approval 15 days before each milestone review.

o A significant T&E Event report must be provided to the DDDRE(T&E) within 24 hours of the test event.

o An End-of-Test Phase Report must be provided to DDDRE(T&E) listing the T&E results, conclusions, and recommendations at least 45 days prior to a milestone decision or the final decision to proceed beyond LRIP.

22.3.6 Director Operational Test and Evaluation (DOT&E)

As illustrated in Figure 22-4, the Director reports directly to the Secretary of Defense and has special reporting requirements to the Congress. The DOT&E's responsibility to Congress is to provide an unbiased window of insight into the operational effectiveness and suitability of new weapon systems.

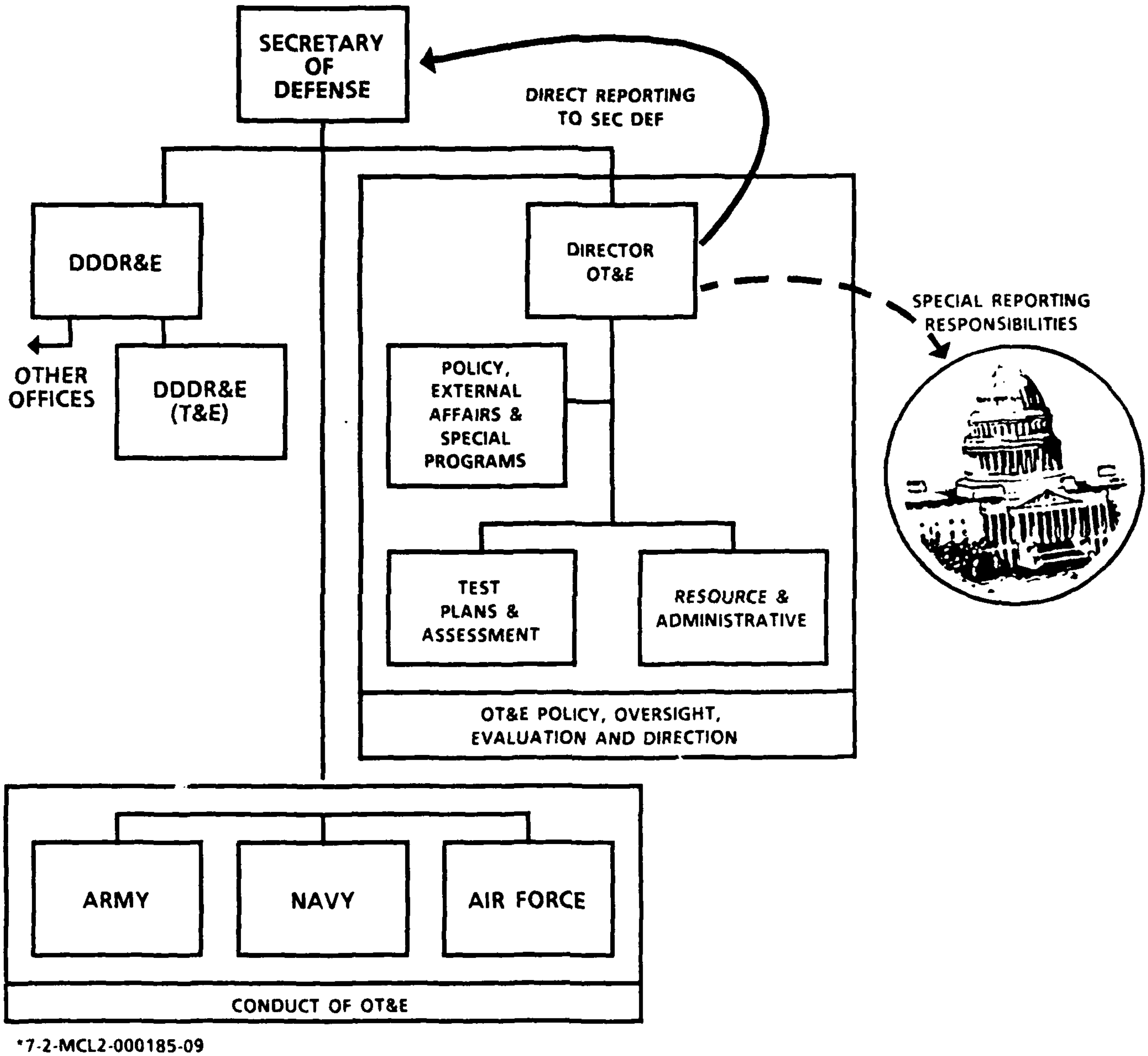


Figure 22-4. The DOT&E Organizational Reporting Structure

22.3.6.1 Duties and Functions of the DOT&E

The specific duties of DOT&E are outlined in DoD Directive 5141.2. The functions of the office include:

- o Obtain reports, information, advice, and assistance as necessary to carry out assigned functions (DOT&E has access to all records and data in DoD on acquisition programs).

- o Signs the TEMPs for approval of OT&E and approves the OT&E funding for major systems acquisition.

- o Approve test plans on all major systems prior to system starting operational test. (Approval in writing is required before operational testing may begin).

- o Provide observers during preparation and conduct of OT&E.

- o Analyze results of OT&E conducted for each major or designated defense acquisition program, and submit a report to the SECDEF and Congress on the adequacy of the operational test and evaluation performed.

- o A final decision to proceed with a major program beyond low-rate initial production (LRIP) cannot be made until DOT&E has reported (LRIP report) to the SECDEF and to Congressional Committees on Armed Services and Appropriations on the adequacy of test and evaluation, and whether the results confirm the system's operational effectiveness and suitability.

22.3.6.2 DOT&E and Service Interactions

For DoD and DOT&E designated acquisition programs, the Service provides the DOT&E the following:

- o A draft copy of the Test Plan for review.

- o Significant Test Plan changes.

- o The final service OT&E report must be submitted to DOT&E at least 45 days prior to the DAB Milestone III review.

- o A briefing on the report and/or independent evaluation of the systems.

22.4 SERVICE T&E MANAGEMENT STRUCTURES

22.4.1 Army T&E Organizational Relationship

The Army management structure for test and evaluation is illustrated in Figure 22-5.

22.4.1.1 Army Acquisition Executive

The Undersecretary of the Army is the Army Acquisition Executive (AAE). The AAE is responsible for all acquisition T&E (operational and developmental tests) planning, programming, budgeting, and developmental tests policy and oversight. The AAE performs these duties with the assistance of the Assistant Secretary of the Army, Research, Development, and Acquisition (ASA/RDA). As illustrated in Figure 22-5, the ASA/RDA is organized to provide technical assessments and program evaluations. He resolves acquisition issues whenever possible and makes recommendations to the AAE on the acquisition of weapon systems. The Deputy Undersecretary of the Army for Operations Research (DUSA(OR)) is chartered to supervise all Army T&E policy and has oversight for all Army T&E.

22.4.1.2 Army Technical Testers and Evaluators

- The U.S. Army Materiel Command (AMC) is responsible for the management of development test and evaluation. The Test and Evaluation Command (TECOM) has the primary responsibility for conducting technical tests for the Army and under certain conditions conducting the evaluation. The TECOM is responsible for:

- Planning, executing and reporting the results of technical tests. Technical tests include Development Tests, Technical Feasibility Tests, Production Qualification Tests, Joint Tests, and contractor/foreign tests.

- Providing test facilities and technical expertise in support of the T&E life cycle.

- Maintaining the Army's Major Range and Test Facility Base.

- Maintaining the Army's T&E data base.

- Researching, developing, and acquiring instrumentation and developing new and improved test methodology.

- Providing safety confirmations.

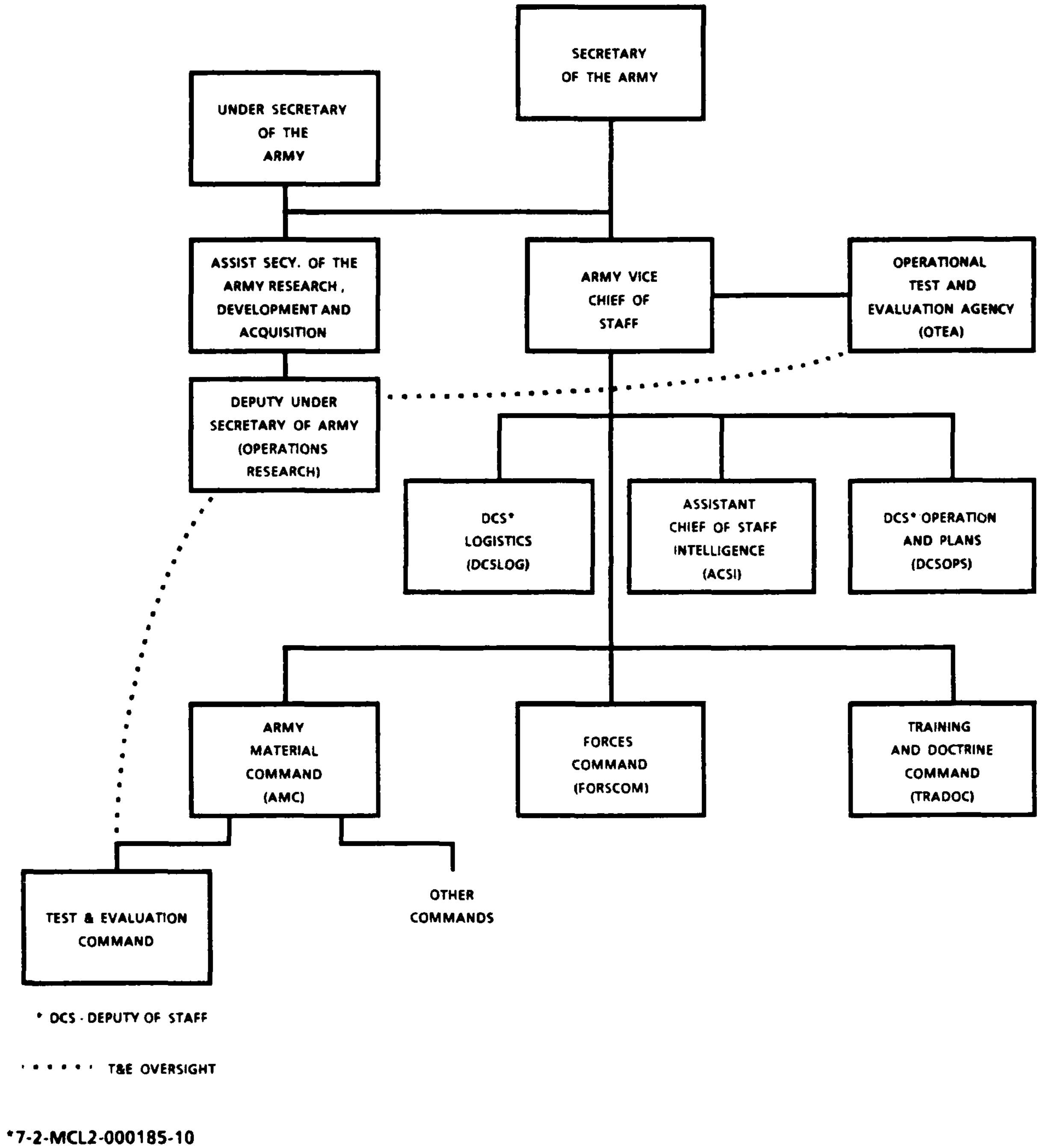


Figure 22-5 Army Management Structure for Test and Evaluation

22.4.1.3 Army Operational Test and Evaluation

o The Army Operational Test and Evaluation Agency (OTEA) is responsible for the management of operational testing of all major and selected nonmajor systems as well as the management of joint user testing. OTEA is an independent agency reporting directly to the Army Vice Chief of Staff.

o The U.S. Army Training and Doctrine Command (TRADOC) supports operational testing by conducting tests on selected nonmajor systems. Operational tests are conducted with doctrine, tactics, and logistic support concepts developed by TRADOC.

o The U.S Army Forces Command (FORSCOM) supports testing by providing user troops and facilities as needed.

22.4.2 Navy T&E Organizational Relationship

The organizational structure for test and evaluation in the Navy is illustrated in Figure 22-6. Within the Navy Secretariat, the Secretary of the Navy has assigned general and specific RDT&E responsibilities to the Assistant Secretary of the Navy (Research, Engineering, and Systems) and to the Chief Naval Operations. The CNO has responsibility for ensuring the adequacy of the Navy's overall test and evaluation program. The T&E policy and guidance are exercised through the Director R&D Requirements and T&E (OP-098) staff support is provided by the Test and Evaluation Division (OP-983) who has cognizance over planning, conducting and reporting all T&E associated with development of systems.

22.4.2.2 Navy DT&E Organizations

The Navy's senior systems development authority is divided among the Commanders of the System Commands with NAVAIR developing and performing DT&E on aircraft, NAVSEA developing and performing DT&E on ships, and SPAWAR developing and performing DT&E on all other systems. System acquisition is controlled by a chartered program manager or by the commander of a systems command. In both cases, the designated developing agency is responsible for DT&E and for the coordination of all test and evaluation planning in the TEMP. Developing Agencies (DA) are responsible for the following testing activities:

o Developing test issues based on the thresholds established by the OPNAV in the Operational Requirement or Navy Decision Coordination paper.

o Identifying the testing facilities and resources required to conduct the DT&E.

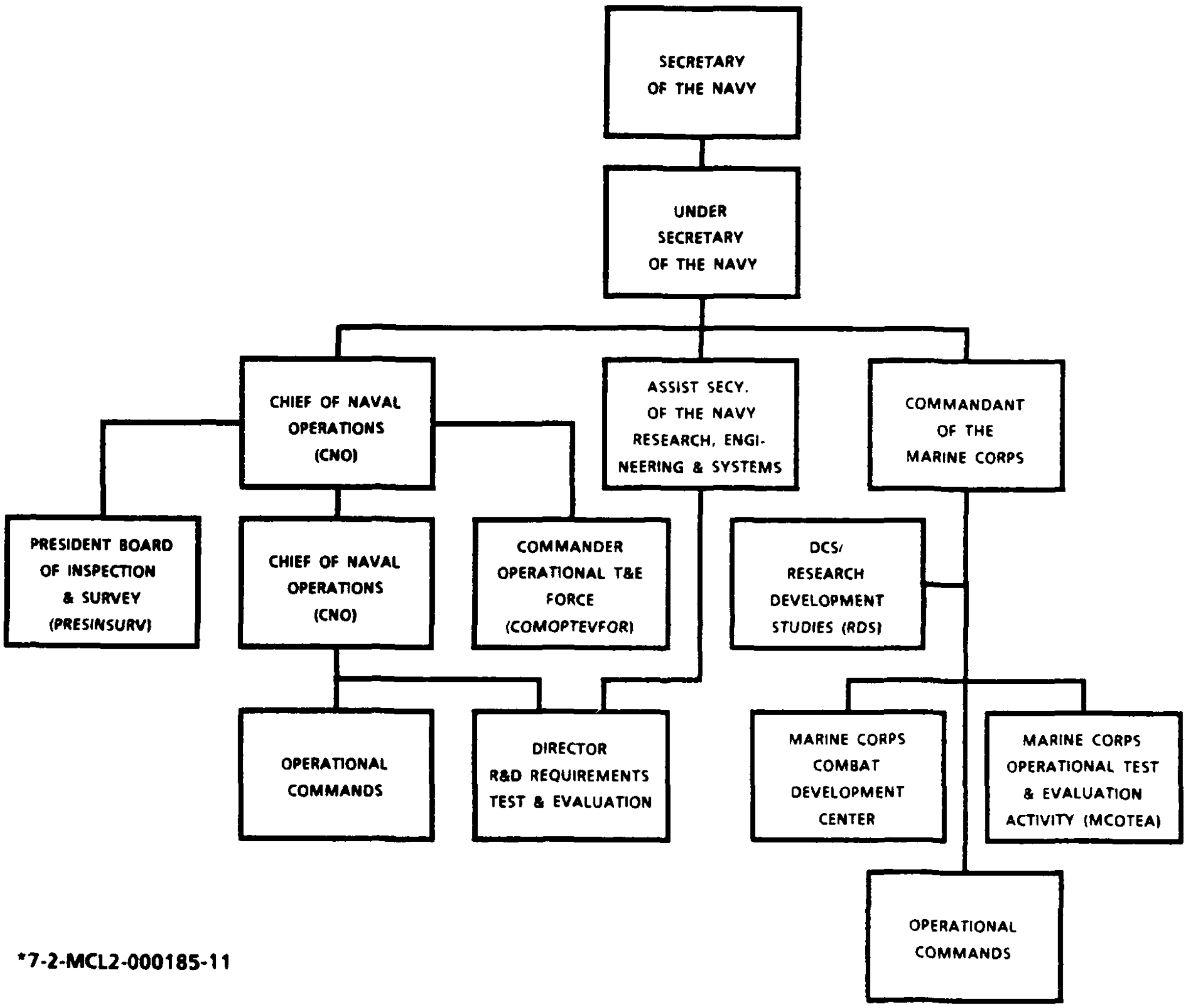


Figure 22-6. Navy Acquisition/T&E Management Structure

- Developing the DT&E test reports and quick-look reports.

22.4.2.3 Navy Operational Test and Evaluation Force

The Commander Operational Test and Evaluation Force (COMOPTEVFOR) commands the Navy's independent operational test and evaluation activity and reports directly to the CNO. The functions of the COMOPTEVFOR include the following:

- Establish early liaison with the DA to ensure an understanding of the test requirements and plans.

- Review acquisition program documentation to ensure that documents are adequate to support a meaningful T&E program.

- Plan and conduct realistic OT&E.

- Develop tactics and procedures for the employment of systems that undergo OT&E (as directed by the CNO).

- Provide recommendations to the CNO for the development of new capabilities or the upgrade of ranges.

- The President of the Board of Inspection and Survey (PRESINSURV) also reports directly to the CNO and is responsible for the conduct of acceptance trials of new ships and aircraft acquisitions. He is the primary Navy authority for Production Acceptance Test and Evaluation of these systems.

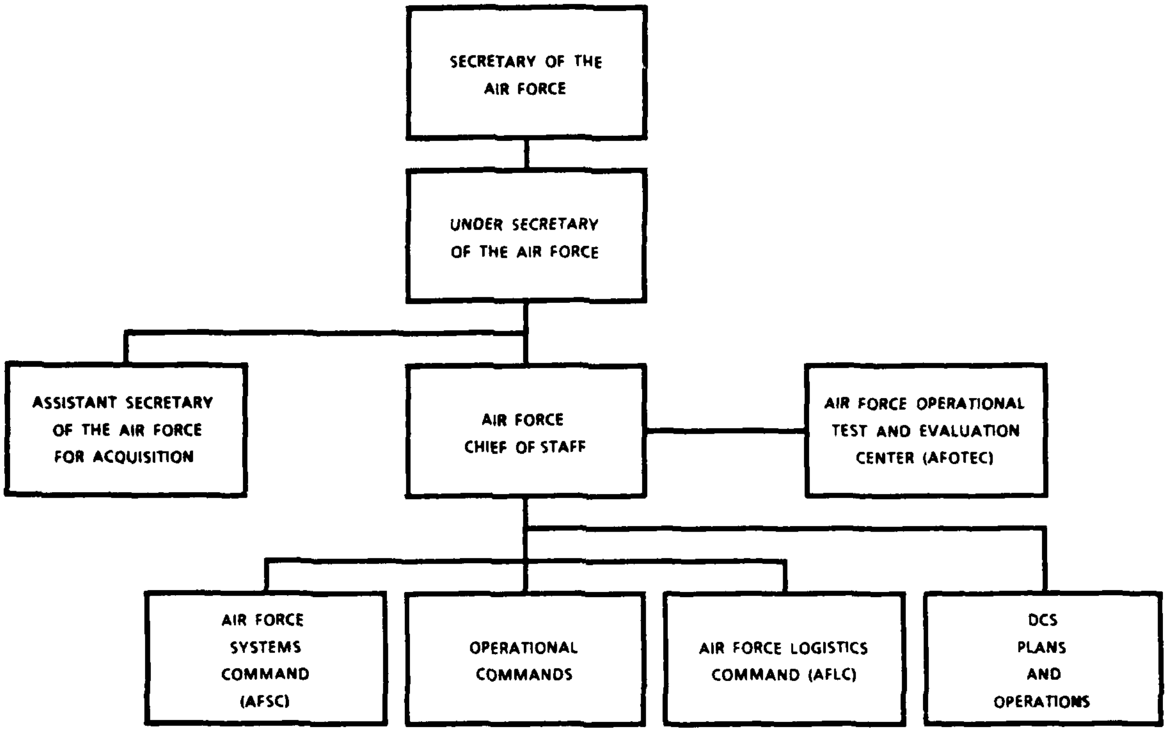
22.4.3 Air Force Organizational Relationships

22.4.3.1 Air Force Acquisition Executive

The Assistant Secretary of the Air Force for Acquisition (ASAF/A) is the senior level authority for research, development and acquisition within the Air Force. As illustrated in Figure 22-7, he is an advisor to the Secretary of the Air Force, interfaces directly with the DDDRE(T&E) and DOT&E. He receives both DT&E and OT&E data and results as a part of the acquisition decision process. The ASAF/A has within his structure a Military Deputy (Acquisition) who is the Air Force's primary staff officer with responsibility for R&D and acquisition. He is the chief advocate of Air Force acquisition programs, develops the RDT&E budget, and is responsible for establishing Air Force T&E Policy.

22.4.3.2 Air Force DT&E Organization

The Air Force Systems Command (AFSC) is the primary DT&E and acquisition manager. The AFSC performs all levels of research, develops



*7-2-MCL2-000135-12

Figure 22-7. Air Force Acquisition/T&E Management Structure weapons systems, support systems, and equipment, and conducts all DT&E. The acquisition program managers are under the command of the Commander, AFSC. Within the AFSC, there are five major product divisions (Aeronautical, Armament, Ballistic Missiles, Electronics, and Space), along with test centers, laboratories, and missile, aircraft and munitions test ranges.

The Air Force Logistics Command (AFLC) can also be a DT&E and acquisition manager. Once the weapon system is fielded and program management responsibility has been transferred from AFSC to AFLC, AFLC may take responsibility for developing and testing system improvements, enhancements, or upgrades.

22.4.3.3 Air Force OT&E Organizations

The Deputy Chief of Staff, Plans and Operations is responsible for supporting and coordinating the OT&E activities of the Air Force Operational Test and Evaluation Center (AFOTEC).

The Commander, Air Force Operational Test and Evaluation Center, is responsible to the Secretary of the Air Force and the Chief of Staff for the independent test and evaluation of all major and selected nonmajor systems acquisitions. He is augmented and supported by the operational commands and others in planning and conducting OT&E.

The Air Force Operational Commands, (SAC, MAC, TAC, USAFE, and PACAF) develop operational requirements, employment concepts, tactics, maintenance concepts, and training requirements and conduct OT&E which is monitored by AFOTEC. The Operational Commands also provide operational concepts, personnel, and resources to assist AFOTEC in performing OT&E and coordinate and provide resources for acquisition programs sponsored by AFSC.

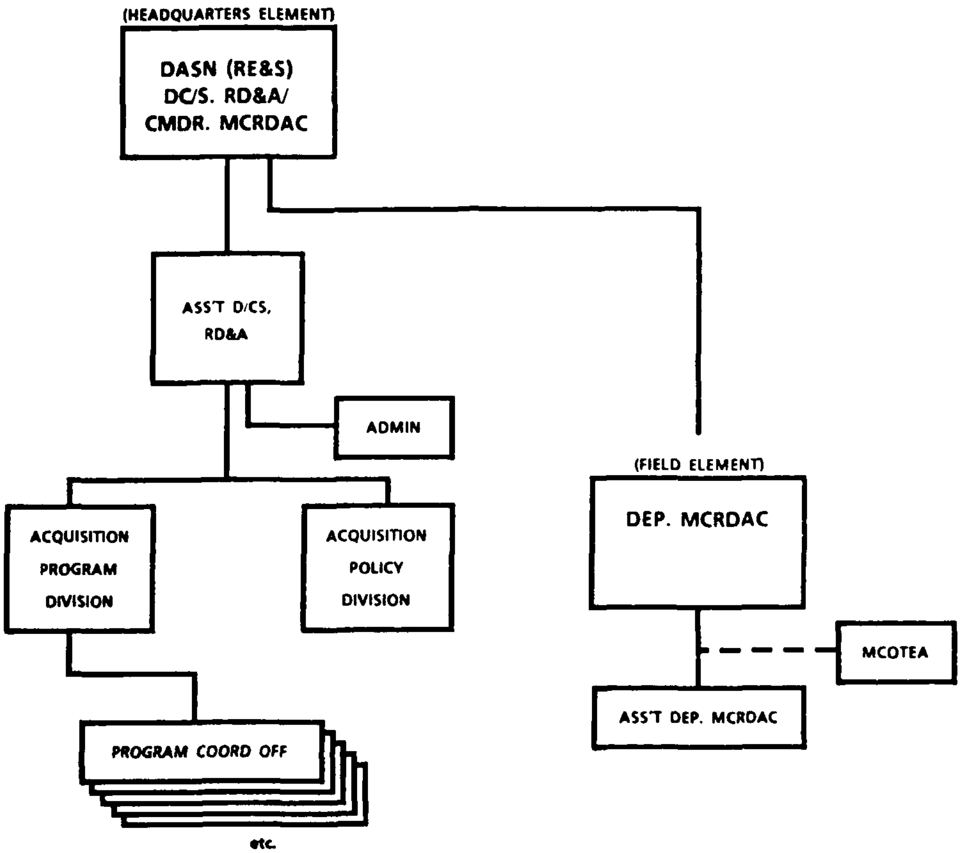
22.4.4 Marine Corps Organizational Relationship

22.4.4.1 Marine Corps Acquisition Executive

The Deputy Chief of Staff for Research and Development (DCS/R&D), Headquarters Marine Corps, directs the total Marine Corps RDT&E effort to support the acquisition of new systems. His position within the General Staff is analogous to that of the Director, RDT&E/OP-098 in the Navy structure. The DCS/R&D also reports directly to the ASN/RE&S in the Navy Secretariat. Figure 22-8, illustrates the Marine Corps organization for test and evaluation management.

22.4.4.2 Marine Corps DT&E Organizations

The Commanding General Marine Corps Research, Development and Acquisition Center (CG MCRD&AC) is the Marine Corps materiel developing



*7-1-MCL2-000584-31

Figure 22-8. Marine Corps Acquisition T&E Management agent and has direct interface with the Navy Systems Commands. The CG MCRD&AC implements policies, procedures, and requirements for DT&E of all systems acquired by the Marine Corps. The Marine Corps also uses DT&E and OT&E performed by other Services which may develop systems of interest to the Corps.

22.4.4.3 Marine Corps Operational Test and Evaluation Agency

The Marine Corps Operational Test and Evaluation Agency (MCOTEA) is the independent OT&E activity maintained by the Marine Corps. Its function is analogous to that performed by OPTEVFOR in the Navy. The CG MCRD&AC provides direct assistance to MCOTEA in the planning, conduct and reporting of OT&E. The Fleet Marine Force performs troop test and evaluation of materiel development in an operational environment.

22.5 SUMMARY

An increased emphasis on test and evaluation has placed greater demands on the OSD and DoD Components to carefully structure organizations and resources to ensure maximum effectiveness. Renewed interest by the Congress on testing as a means of assessing systems utility and effectiveness and a recent report by the President's Blue Ribbon Panel on Acquisition Management have resulted in major reorganizations within the Services. These reorganizations will be ongoing for several years to improve the program management and test and evaluation of acquisition systems.

CHAPTER 23

PROGRAM OFFICE RESPONSIBILITIES FOR TEST AND EVALUATION

23.1 INTRODUCTION

In Government Program Management Offices (PMO), there should be an element dedicated to management of Test and Evaluation. This element would have the overall test program responsibility for all phases of the acquisition process. In the PMO, the Deputy for Test and Evaluation (T&E) would be responsible for defining the scope and concept of the test program, establishing the overall program test objectives and managing test program funds and coordination. The Deputy for T&E should provide test directors as required, such as a Joint Test Director, and coordinate the test resources, facilities, and their support required for each phase of testing. In addition, he or a member of his staff, will be responsible for managing the Test and Evaluation Master Plan (TEMP) and planning and managing the special test programs required for the program. The Deputy (T&E) will also review, evaluate, approve, and release for distribution, contractor prepared test plans and reports, and review and coordinate all appropriate government test plans. After the system is produced, he will be responsible for supporting Product on Acceptance Testing and the test portions of P^3I upgrades or enhancements to the weapon system/acquisition. If the program is large enough, Deputy (T&E) will be responsible for all T&E direction and guidance on that program.

23.2 RELATIONSHIP TO THE PROGRAM MANAGER

The Program Manager (PM) is ultimately responsible for all aspects of the system development, to include testing. The Deputy (T&E) is normally authorized by the Program Manager to conduct all duties in the area of test and evaluation. The Deputy (T&E) input to the contract, engineering specifications, budget, program schedule, etc. is essential for the Program Manager to efficiently manage the program.

23.3 EARLY PROGRAM STAGES

In the early stages of the program, the Deputy (T&E) writes the test sections of the Request for Proposal (RFP). Although the ultimate responsibility for the RFP is between the Program Manager (PM) and the Primary Contracting Officer (PCO), the Deputy (T&E) has the responsibility for creation of several sections. These sections include the test schedule, test program funding (projections), test data requirements for the program (test reports, plans, procedures, quick-look reports, etc.), the test section of the Statement of Work (SOW), the Acquisition Plan, Information for Proposal Preparation (IFPP), and if a joint acquisition program, the Joint Requirements Document (JRD).

23.3.1 Memorandums

Another task of the Deputy (T&E) early in the program is the arrangement of any Memorandums of Agreement or Understanding (MOA/MOU) between either Services, NATO countries, Test Organizations, etc. which outline the responsibilities of each organization. The RFP outlines contractor/Government obligations and arrangements on the access and use of test facilities (both contractor and Government owned).

23.3.2 Test Data Management

The Deputy (T&E) may have approval authority for all contractor created test plans, procedures, and reports. He must have access to all contractor testing and test results and he is responsible for disseminating the results to Government agencies that need this data. Additionally, the Deputy creates report formats and time lines for contractor submittal, government approval, etc.

The data requirements for the entire test program are outlined in the Contract Data Requirements List (CDRL). The Deputy (T&E) provides input to this section of the RFP early in the program. He ensures that his office and all associated test organizations requiring the information are distributed the test documentation in a timely manner. Usually, the contractor sends the data packages directly to the Deputy (T&E) who, in turn, has a distribution list trimmed down to the minimum amount of copies for agencies needing that information to perform their mission and oversight responsibilities. It is important for the Deputy (T&E) to use an integrated test program and request contractor test plans and procedures well in advance of the actual performance of the tests to ensure his office has time to approve the procedures and effect corrections or modifications. Conversely, he must also receive the test results and reports in a timely manner to enable him, the program manager, and higher authorities to make program decisions. Further, the data received should be tailored to provide the minimum information and copies needed. The Deputy (T&E) must remain aware of the fact that data requirements in excess of the minimum needed will lead to an unacceptable increase in overall program cost. For data that is needed quickly and informally (at least initially), the Deputy (T&E) can request Quick-Look Reports that give test results immediately after test performance. The Deputy (T&E) is also responsible for coordinating with the contractor on all report formats (usually the in-house contractor format is acceptable in most cases).

23.3.3 Test Schedule Formulation

A very important task the Deputy (T&E) has for the creation of the RFP is the test program schedule. Initially, the program manager will need contractor predictions of the hardware (and software in some cases) availability dates for models, prototypes, mockups, full-scale models, etc. once the contract is awarded. The Deputy (T&E) uses this information to create a realistic front-end schedule of the in-house testing the contractor will conduct prior to government testing (DT & OT). Then, a "strawman" schedule is developed upon which the government DT and OT schedules can be formulated and contractor support requirements determined. The Deputy (T&E) can use past experience in testing similar weapon systems/acquisition items or contact test organizations which have the required experience to complete the entire test schedule. Since the test schedule is a critical contractual item, the contractor's inputs are very important. The test schedule will normally become an item for negotiation once the RFP is released and the contractor's proposal received. Attention must be given to ensuring the test schedule is not so "success oriented" in such a way that any test failures will result in serious consequences for either the government test agencies or the contractor.

23.4 PMO/CONTRACTOR TEST MANAGEMENT

The PMO will, in most cases, have a contractor test section counterpart. With this counterpart, the Deputy (T&E) works out the detailed test planning, creation of schedules, etc. for the entire test program. The PMO uses inputs from all sources (contracts, Development Test Agencies, Operational Test Agencies, Higher Headquarters, etc.) to formulate the test program's length, scope, and necessary details. The Deputy (T&E) ensures that the RFP reflects the precise test program envisioned and the contractor's role in the acquisition. He also ensures that the RFP includes provisions for Government attendance at contractor's tests and that all contractor test results are provided to the Government.

Once the RFP has been submitted and the contractor's proposal is received, it is reviewed by the PMO. The Deputy (T&E) is responsible for performing a technical evaluation on the test portions of the proposal. In this technical evaluation, he compares the proposal to the Statement of Work, test schedule, IFPP, etc. and reviews the contractor's costing of each testing item. This is an iterative process of refining, clarifying, and modifying that will ensure the final contract between the PMO and the Prime Contractor (Subcontractors) contains all test related tasks and is priced within scope of the proposed test program. Once technical agreement on the contractor's technical approach is reached, the Deputy (T&E) is responsible for giving inputs to the government contracting officer during contract negotiations. The contracting officer requests contract deliverables to which are assigned contract line item numbers (CLIN) which are created by the Deputy (T&E). This will ensure the Contractor delivers the required performances at specified intervals during the life of the contract. Usually, there will be separate contracts for development and production of the acquisition item. For each type of contract, the Deputy (T&E) has the responsibility to provide the PCO and PM with the test and evaluation inputs to each.

23.5 TEST PLANNING WORKING GROUPS

Prior to the creation of the final version of the RFP, the Deputy (T&E) will form a test planning working group. This group includes the Operational Test Agency, Development Test Agency, any organizations that may be jointly acquiring the same system, the test supporting agencies, operational users, and any other organizations that will be involved in the test program by providing test support, conducting, evaluating, or reporting on testing. In most cases, the contractor participates in this test planning group; however, the contractor may not be selected by the time the first meetings are held.

The purpose of these meetings are to review and assist in the development of the Test and Evaluation Master Plan (TEMP) and to reach agreement on basic test program schedules, scope, support, etc. The TEMP serves as the top level test management document for the acquisition program, changing and being updated as the test program dictates in the future.

23.6 TEST PROGRAM FUNDING/BUDGETING

The PMO must identify funds for testing very early so that test resources can be obtained. The Deputy (T&E) uses the acquisition schedule, TEMP and other program and test documentation to identify test resource requirements. He coordinates these requirements with the Government organizations that have the test facilities to ensure their availability for testing. The Deputy T&E ensures that test costs include both the contractor and the government test costs. The contractor's test costs are normally adequately outlined in his proposal, whereas the Government test ranges, instrumentation, and test support resource costs must be determined by other means. Usually, the Deputy (T&E) contacts the test organization, outlines his test program requirements and the test organization sends the program office an estimate of the test program costs. He then obtains cost estimates from all test sources he anticipates using and supplies this information to the Program Manager. The Deputy (T&E) must also ensure that any funding reductions on the program are not absorbed entirely by the test program. Some cutbacks may be necessary and allowable, but the test program must supply him, other defense decision making authorities, and Congress with enough information to make program milestone decisions.

23.7 TECHNICAL REVIEWS, DESIGN REVIEWS, AND AUDITS

The role of the Deputy (T&E) changes slightly during the contractor's technical reviews, design reviews, physical and functional configuration audits, etc. Whereas, usually he plans, directs, or monitors government testing, in the reviews and audits, he examines the contractor's approach to the test problem and evaluates the validity of the process and the accuracy of the contractor's results. Using his experience and background in test and evaluation, he also assesses whether the contractor did enough or too little testing, whether the tests were biased in any way, and if they followed a logical progression using the minimum of time, effort, and funds. If the Deputy (T&E) finds any discrepancies, he must inform the contractor, the program manager, and the primary contracting officer to validate his conclusions and then effect corrections. Each type of review or audit will have a different focus/orientation, but the Deputy (T&E) will always be concerned with the testing process and how it was carried out. After each review, the Deputy (T&E) should always document his observations for future reference.

23.8 CONTRACTOR TESTING

The Deputy (T&E) is responsible for monitoring all contractor conducted tests. He must also be given access to all contractor internal data, test results, and test reports related to his acquisition program. Usually, the contract outlines the requirement that the government representatives be informed ahead of time of any (significant or otherwise) testing the contractor conducts so the government can arrange to witness the testing or receive results of the tests. Further, the contractor's internal data should be available as a contract provision. The Deputy (T&E) must ensure that Government test personnel (DT&E/OT&E) have access to contractor test results. It would be desirable to have all testers observe the contractor tests to help develop confidence in the system and identify areas of risk.

23.9 SPECIFICATIONS

Within the program office, the Engineering Section is usually tasked to create the preliminary specifications for release of the RFP. The contractor is then tasked with creation of the specifications in the contract, which will be delivered once the item/system design is formalized for production. The Deputy (T&E) becomes involved in specification formulation in an important way. He reviews the specifications with an insight to determine if they are testable, if current technology or state-of-the-art technical means can determine (during the DT&E test phase) if the spec's are being met by the acquisition item, or if the specification is too "tight". A specification is too "tight" if the requirements are impossible to meet or test towards, or the specification has no impact on appearance or performance of the end item, the system it will become a part of or the system it will interact with. He must determine if test objectives can be adequately formulated from those spec's at later dates that will provide thresholds of performance, minimum and maximum standards, and reasonable operating conditions for the end item's final purpose and operating environment. The specifications shape the DT&E testing scenario, test ranges, test support, targets, etc. and so are very important to the Deputy (T&E).

23.10 INDEPENDENT EVALUATION AGENCIES

The PMO Deputy (T&E) does not have direct control over government-owned test resources, test facilities, test ranges, test personnel, etc. Therefore, he must depend on those test organizations controlling them. However, the Deputy (T&E) must stay involved with the test agency activities. The amount of involvement depends on the item being tested, its complexity, cost, characteristics, the length of time for testing, amount of test funds, etc. Usually, the "nuts & bolts" detailed test plans and procedures are written by the test organizations controlling the test resources with inputs and guidance from the Program Office (Deputy (T&E)). The Deputy (T&E)'s responsibility is to ensure that the tests are performed using test objectives based upon the specifications and that the requirements of timeliness, accuracy, and minimal costs are met by the test program design. During the testing, the Deputy (T&E) monitors the testing. The test agencies submit their a copy of their report to the Program Office at the end of testing, usually to the Office of the Deputy (T&E).

CHAPTER 24

PROGRAM MANAGEMENT OPERATIONAL TEST RESPONSIBILITIES

24.1 INTRODUCTION

In the Government Program Management Office (PMO), there is a section dedicated to Test and Evaluation (T&E). Besides being responsible for Development Test & Evaluation (DT&E) support to the Program Manager, this section is also responsible for the program coordination of Operational Test and Evaluation (OT&E). The office of the Deputy for Test and Evaluation (Deputy (T&E)) is designated to provide this support to the Program Manager. In some Services, responsibilities of the Deputy (T&E) include coordination of test resources for all phases of OT&E.

24.2 CONTRACT RESPONSIBILITIES

The Deputy (T&E), or his representative, ensures that certain sections of the Request for Proposal (RFP) contain sufficient allowance for T&E support by contractors. This applies whether the contract is for a development item, a production item (limited production, such as LRIP or full-rate production) or the enhancement/upgrade of portions of a weapons system. Where allowed, within the law, contractor support should be considered to help resolve basic issues such as data requirements, test schedules, contractor test support and funding.

In the overall portion of the RFP, all Government personnel, especially those in the Operational Test Agencies, must be guaranteed access to the contractor's development facilities, especially during the DT&E phase. The Government representatives must be allowed to observe all contractor in-house testing and have access to his test data and reports.

24.2.1 Data Requirements

The contract must specify the data the contractor must supply during OT&E. Unlike DT&E, the contractor will not be making the test plans, procedures, or reports. These documents are the responsibility of the Operational Test Agency (OTA). The Deputy (T&E) should include the OTA on a distribution list for all test documents which may concern them during the DT&E phase of testing to keep them informed on the test item's progress and previous testing. In this way, the OTA will be better informed when developing their own test plans and procedures for OT&E. In fact, the OTA should attend the Contract Data Requirements List (CDRL) Review Board and list for the PMO the types of documents the OTA will need. The Deputy (T&E) should coordinate the test sections of this data list with the OTA and then represent their concerns in that meeting. All tests the contractor performs should be reported and copies of those reports made available to the OTA. In return, the Deputy (T&E) must ensure that he is kept informed about all OTA activities and receive their test procedures, test plans, and their test reports. Unlike DT&E, the Deputy (T&E) will not have report or document approval authority as he does over the contractor's documentation. The Deputy (T&E) is always responsible for keeping the program manager informed on OT&E progress.

24.2.2 Test Schedule

Another important early activity the Deputy (T&E) must accomplish is to determine the OT&E test schedule. Since the contractor may need to provide support (depending on whether the contractor will maintain the acquisition item in the field once operational), the test schedule may need to be contractually agreed to before contract award. Sometimes, the Deputy (T&E) can formulate a strawman schedule (based on previous experience with like items) and then present this schedule to the operational test representative at the initial test planning working group for their review. Or, he can simply contact the OTA, arrange a meeting to discuss the new program, and in that meeting discuss time requirements that the OTA envisions. That input then goes into the RFP and to the Program Manager. The test schedule must allow for time between DT&E testing and OT&E testing if the testing is not combined or the test assets are limited. That time gap is necessary for review of DT&E test results, set-up of OT&E, refurbishment or corrections of deficiencies discovered during DT&E, etc. The test schedule for DT&E should not be so "success oriented" that the OT&E test schedule is adversely impacted, not allowing enough time for adequate testing, or the reporting of OT&E results. For example, if the DT&E schedule slips 6 months, the OT&E schedule and the milestone decision should slip also. In the event of a schedule slip, OT&E should not be shortened just to make a milestone decision date.

24.2.3 Contractor Support

The Deputy (T&E), being responsible for providing all T&E inputs to the RFP, must determine early in the program acquisition phase, whether the contractor will be involved in supporting OT&E and, if so, to what extent that support will be. According to Congress, the contractor can only be involved in the conduct of OT&E if, once the item is fielded, the contractor will be providing the support of that item or operating that item. If not, no contractor support is allowed during OT&E. Prior to OT&E, however, the contractor may be tasked with providing training and handbooks to typical operational users and maintenance personnel. In addition, the contractor must be required to provide sufficient spare parts for the operational maintenance personnel to maintain the test item while undergoing operational testing. These support items must be agreed to by the PMO and OTA and then made contractually binding on the contractor. If, however, the contractor will be required to provide on-site maintenance of the item for the duration of its useful life, then the contractor will be allowed (and obligated) to participate in OT, to include spare parts, training, etc.

24.2.4 OT&E Funding

The Deputy (T&E) helps provide the Program Manager estimates of all test program costs to conduct pre-production OT&E. This funding includes both contractor and Government test support for which the Program Office directly or indirectly will be responsible. Some OTA support is funded by the Program Office for conducting OT&E on Government test ranges. The Deputy (T&E) must determine these costs and inform the Program Manager. The contractor's funding for DT&E will be handled by the contracts (development and production).

24.2.5 Statement of Work

The most important document the Deputy (T&E) provides inputs to is the Statement of Work (SOW). In this document, he must outline all required anticipated contractor support for DT&E and OT&E. This document outlines the data requirements, contractor conducted or supported testing, government involvement (access to the contractor's data, tests, and results), operational test support, and any other specific test requirements the contractor will be tasked to perform during the duration of the contract.

24.3 TEST AND EVALUATION MASTER PLAN

The Test and Evaluation Master Plan (TEMP) should be updated as required during OT. The Deputy (T&E) is responsible for managing the TEMP throughout the test program. The Operational Test Agency usually is tasked to complete the operational test section of the TEMP and provide Operational Test Plans (OTPs) outlining their proposed test program through all phases of OT&E. It is important to keep the TEMP updated regularly so that test organizations involved in OT&E understand the scope of their test support. Further, if any upgrades, improvements, or enhancements to the fielded weapon system occur, the TEMP must be updated or a new one created to include any new DT and OT requirements.

24.4 PHASES OF OPERATIONAL TEST

The Deputy (T&E) performs different roles during each phase of operational test. The phases include Initial Operational Test & Evaluation (IOT&E) and Follow-On Operational Test & Evaluation (FOT&E). For IOT&E, the Deputy (T&E) must ensure the contract portions are adequate to cover the scope of testing as outlined by the Operational Test Agency. The Program Office may also provide a Test Director to represent the Deputy (T&E) during the actual testing. The Deputy (T&E)'s involvement in IOT&E will be more of a monitoring and coordination mode wherein he keeps the Program Manager informed of progress and problems that arise through testing and provides whatever support to the test organization that is required. For any problems requiring Program Office support, the Deputy (T&E) will be the point of contact.

During IOT&E, the Deputy (T&E)'s responsibility is to ensure the contract allows adequate insight into contractor production testing, to include qualification testing. Further, the production contract has to outline contractor support of operational testing, to include the production of adequate spare parts the Service's maintenance personnel will need to maintain the acquisition item/weapon system during OT&E. Also, enough Low-Rate Initial Production (LRIP) items must be manufactured to run a complete and adequate OT&E program. If the contractor will maintain the item in the field, then the contractor must be a part of the IOT&E.

During FOT&E, the Deputy (T&E) monitors the testing and usually no contractor or contract is involved with this phase. If inadequacies are noted during FOT&E, the program manager and the engineering section of the Program Office may design or develop modifications, which may be incorporated into the weapon system design. The Deputy (T&E) should receive any reports generated by the operational testers during this time. Any deficiencies noted during FOT&E should be reported to the PMO which may decide to incorporate upgrades, enhancements, or additions to the current system.

24.5 UPGRADES, ENHANCEMENTS, ADDITIONS

Once a weapon system is fielded, portions of that system may become obsolete, ineffective, or deficient and need replacement, upgrading, or enhancing to ensure the weapon system can meet current and future requirements. The Deputy (T&E) plays a vital role in this process. The modifications to existing weapon systems must be managed, as would entire newly acquired weapon systems. However, since these are changes to existing systems, the Deputy (T&E) has the responsibility to determine if these enhancements degrade the existing system, are compatible with its interfaces and functions, and whether the Nondevelopment Items (NDIs) require retest, or the entire weapon system needs re-verification. The Deputy (T&E) must plan the test program's funding, schedule, test program, and contract provisions with these items in mind. A new TEMP may have to be generated or the original weapon system TEMP modified and re-coordinated with the test organizations. The design of the test program usually requires coordination with the engineering, contracting, and program management sections of the Program Office.

24.6 POST-PRODUCTION DECISION ACTIVITIES

The Deputy (T&E) will be involved with OT&E of the actual production units after a limited number are produced. The IOT&E that occurs at that time must be closely monitored so that a full-rate production decision can be made. As in the Operational Assessments, the Deputy (T&E) will be monitoring test procedures and results and keep the Program Manager informed. If the item does not succeed during IOT&E, a new process of DT&E, or modification, may result in which the Deputy (T&E) will be involved (as in any new programs inception). If the item passes IOT&E testing and is produced at full rate, the Deputy (T&E) will be responsible for ensuring that testing of those production items is adequate to ensure that those end items physically and functionally resemble the development items.

24.7 INDEPENDENT EVALUATION AGENCIES

During the IOT&E, the Service Operational Test Agency (OTA) controls all aspects of testing, to include test plans, procedures, reports, etc. The OTA uses the resources of other organizations to test the item in an operational environment using as many actual end item operators as possible. The Deputy (T&E)'s role for IOT&E testing includes ensuring enough funds are projected for operational testing, assisting the OTA in the coordination of test resources (including contractor support) for OT, monitoring OT&E and providing other test support as required by the OTA. The OTA will make their own independent evaluation of OT and forward copies to the Program Office after testing is complete. The results of testing, however, are usually required long before the report is finished for the production decision.

24.8 TEST RESOURCES

During all phases of OT, the Deputy (T&E) must be concerned with ensuring the operational testers have the test resources they need to accomplish their mission. Test resources will be either contractor owned or Government owned. The contractor resources must be covered in the contract, whether in the development contract (IOT&E) or the production contract (FOT&E). The Government test resources used are determined by the operational testers. They usually coordinate the test ranges, test support, and the personnel for testing. The program manager identifies funding for his support of OT. The funds are released to the OTA to use for their test program. The OTA then makes a budget and obligates funds for test ranges, instrumentation, etc. according to their operational test plans.

CHAPTER 25

T&E OF WEAPON SYSTEMS TYPES

25.1 INTRODUCTION

This chapter will offer guidance to Department of Defense personnel whose task it is to plan, monitor, and execute test and evaluation. Checklists for the chapter were obtained from the Defense Science Board Study, entitled: Report of Task Force on Test and Evaluation, dated April 2, 1974. This excellent study is highly regarded in the Test & Evaluation (T&E) community. It has become dated and the Defense Systems Management College decided to update the study findings and include those findings and summary checklists in this management guide.

25.2 General Test and Evaluation Issues

The Defense Science Board (DSB) report presented guidance on T&E at two levels. At the more general level, it discussed a number of general issues which were appropriate to all weapon acquisition programs. These issues, along with a summary discussion are given below.

25.2.1 Effects of Test Requirements on System Acquisition

The acquisition strategy for the system should allow sufficient time between the end of demonstration testing and procurement, as contracted with limited production decisions, to allow flexibility for modification of plans which will be required; ensure that sufficient dollars are available not only to conduct T&E but to allow for the additional T&E which is always required due to failure, design changes, etc.; and, be evaluated relative to constraints imposed by:

- The level of system testing at various stages of the RDT&E cycle,
- The number of test items available and the schedule interface with other systems needed in the tests, such as aircraft, electronics, etc.
- The support required to assist in the preparation, conduct of the tests, and the analysis of the test results;
- Be evaluated to minimize the so-called T&E gap caused by lack of hardware during the test phase.

25.2.2 Test Requirements and Restrictions

Tests should:

- o Have specific objectives;
- o List in advance actions to be taken as a consequence of the test results;
- o Be instrumented to permit diagnosis of the cause of lack of performance including random, design induced, wearout, and operator error failure; and
- o Not be repeated if failures occur, without a detailed analysis of the failure. ("Most likely the failure will not go away.")

25.2.3 Trouble Indicators

Establish an early detection scheme to identify program illness.

When a program begins to have trouble there are indicators which will show up during testing. Some of these indicators are:

- o A test failure;
- o Any repetitive failure;
- o A revision of schedule or incremental funding that exceeds the original plan; or
- o Any relaxation of the basic requirements such as lower performance.

25.2.4 Requirement For Test Rehearsals

Test rehearsals should be conducted for each new phase of testing.

25.3 SCHEDULING

Specific issues associated with test scheduling are listed below.

25.3.1 Building Block Test Scheduling

The design of a set of tests to demonstrate feasibility prior to the Full-Scale Development Phase should be used. This will allow high technical risk items to be tested early and subsequent tests to be incorporated into the hardware as the system concept has been demonstrated as feasible.

25.3.2 Component and Subsystem Test Plans

Ensure a viable component and subsystem test plan. Studies show that almost all component failures will be the kind that cannot be easily detected or prevented in full system testing. System failure must be detected and fixed in the component/subsystem stage as detecting failure only at the operational test level makes the cost of correcting such failures very high.

25.3.3 Phasing of DT&E and IOT&E

Problems that become apparent in the operational testing can often be evaluated much more quickly with the instrumented DT&E hardware. The integrated test plan should allow for time and money to investigate test failures and make provisions for eliminating the cause of the failures before other similar tests take place.

25.3.4 Scheduling IOT&E To Include System Interfaces With Other Systems

Whenever possible, the IOT&E/FOT&E of a weapon system should be planned to include other systems which must have a technical interface with the new system. For example, the missile should be tested on most of the platforms for which they are programmed.

25.4 RESOURCES FOR TESTING

25.4.1 Identification Of Test Resources and Instrumentation

As early as possible, but not later than the start of the Full-Scale Development phase, the test facilities and instrumentation requirements to conduct operational tests should be identified, along with a tentative schedule of test activities. This information is recorded in the Test and Evaluation Master Plan (TEMP) and Service test resource documentation.

25.4.2 Requirement For Multiservice OT&E

Multiservice OT&E should be considered for those weapon systems which require new operational concepts involving other Services. If multiservice testing is used, an analysis of the impact of demonstration on time and resources needed to execute the multiservice tests should be conducted before the Milestone II decision.

25.4.3 Military Construction Program Facilities

Some programs cannot be tested without Military Construction Program facilities. To construct these facilities will require long lead times therefore, early planning must be done to ensure that the facilities will be ready when required.

25.4.4 Test Sample Size

The primary basis for the test sample size is usually based on one or more of the following:

- Analysis of test objectives;
- Statistical significance of test results at some specified confidence level;
- Availability of test vehicles, items, etc.;
- Support resources or facilities available; or
- Time available for the test program.

25.4.5 Test Termination

One should not hesitate to terminate a test prior to its completion when it becomes clear that the main objective of the test is unachievable (because of hardware failure, unavailability of resources, etc.), or that additional samples will not change the outcome and conclusions of the test.

25.5 COST

25.5.1 Budgeting For Test

The DCP, TEMP, and later budgeting documents should be regularly reviewed to ensure that there are adequate identified funds for testing, relative to development and fabrication funds.

25.5.2 Funds For Correction Of Faults Found In Testing

The DCP, TEMP and later budgeting documents need careful scrutiny to ensure that there are adequate contingency funds to cover correction of difficulties at a level that matches the Industry/Government experience on the contract. (Testing to correct deficiencies found during testing without sufficient funding for proper correction, results in band-aid approaches which ultimately require corrections at a later and more expensive time period.)

25.6 PERFORMANCE AND OPERATIONAL ISSUES

25.6.1 Proof Of Performance Of Human Factors Concepts

At an appropriate time in Concept Exploration/Definition or Concept Demonstration/Validation phases, T&E should authenticate the human factors concepts embodied in the proposed systems design, examining questions of safety, comfort, man-machine interfaces, as well as the number and skill of personnel required.

25.6.2 Test Planning

A summary of important test planning items that were identified by the DSB are provided below:

- Ensure that the whole system, including the system user personnel, are tested. Realistically test the complete system, including hardware, software, people and all interfaces. Get user involved from the start and understand user limitations.
- Ascertain that sufficient time and test articles are planned. When the technology is stressed, the higher risks require more test articles and time.
- In general, parts, subsystems and systems should be proven in that order before incorporating them into the next higher assembly for more complete tests. The instrumentation should be planned to permit diagnosis of trouble.
- Major tests should never be repeated without an analysis of failure and corrective action. Allow for delays of this nature.

25.7 SPECIFIC WEAPON SYSTEMS TESTING CHECKLIST

The DSB report is the result of the study of past major weapon systems acquisitions. It was hoped that this study would enhance the testing community's understanding of the role which test and evaluation has had in identifying system problems during the acquisition process. In the foreword of the DSB study, the authors made this statement about including the obvious testing activity in their checklist:

> The T&E expert in reading this volume will find many precepts which will strike him as of this type. These items are included because examples were found where even the obvious has been neglected, not because of incompetence or lack of personal dedication by the people in charge of the program, but because of financial and temporal pressures which forced competent managers to compromise on their principles. It is hoped that the inclusion of the obvious will prevent repetition of the serious errors which have been made in the past when such political, economical and temporal pressures have forced project managers to depart from the rules

of sound engineering practices... In the long run, taking short cuts during T&E to save time and money will result in significant increases in the overall costs of the programs and in a delay of delivery of the corresponding weapon systems to combatant forces.

25.7.1 Aircraft Systems

25.7.1.1 Concept Exploration/Definition Phase

o Test Program/Total Costs. Prior to Milestone I, all the phases of the aircraft test program should be considered so that the total costs and the development schedules include consideration of all likely activities in the overall program.

o Test Facilities and Instrumentation. Prior to Milestone I, the test facilities and instrumentation requirements to conduct tests should be generally identified along with a tentative schedule of test activities.

o Test Resources and Failures. Ensure that there are adequate funds, reasonable time and an acceptable number of aircraft planned for the various test program phases and that these make provisions for the occurrence of failures.

o System Interfaces. Consider all aircraft system interfaces, their test requirements and probable costs at the outset of the Concept Exploration/Definition phase.

o Major Weapon Subsystems. If the aircraft system relies on the successful development of a specific and separately funded major weapon (such as a gun or missile) in order to accomplish its primary mission, this major subsystem should be developed and test concurrently with or prior to the aircraft.

o Propulsion System. If the aircraft program is paced by the propulsion system development, an early advanced development project for the propulsion may be appropriate for a new concept.

o Operational Scenario. A conceptual operational scenario for operation and use of the aircraft should be developed so that general test plans can be designed. This should include purpose, roles and missions, threats, operating environments, logistics and maintenance, and basing characteristics. The potential range of values on these aspects should be stated.

o Evaluation Criteria. Develop evaluation criteria to be used for the selection of the final aircraft system design.

- o Untried Elements. The aircraft development program should include conclusive testing to eliminate uncertainties of the untried elements.

- o Brassboard Avionics Tests. The use of brassboard or modified existing hardware to "prove" that the concept will work should be seriously scrutinized to ensure that the demonstrations and tests are applicable.

- o Nuclear Weapons Effects. The subject of nuclear weapons effects should be addressed in the test concept for all aircraft weapons systems where operational suitability dictates that survivable exposure to nuclear weapons effects is a requirement.

25.7.1.2 Concept Demonstration/Validation Phase

- o By the end of the validation phase, test and evaluation plans and test criteria should be established so there is no question as to what constitutes a successful test and what performance is required.

- o Milestones and Goals. Assure an integrated system test plan that pre-establishes milestones and goals for easy measurement of program progress at a later time.

- o Operating Concept and Environment. The operational concept and it environments in which the aircraft will be expected to operate and to be tested in OT&E should be specified.

- o Test Program Building Blocks. In the validation phase, demonstrate that the high risk technology is in hand and in planning the full-scale development test program ensure components and the subsystems are adequately qualified for incorporation into the system tests.

- o Technology Concepts. Each concept to be used in the aircraft system (e.g., aerodynamics, structures, propulsion) should be identified and coded according to prior application, prior to future research; tests for each of the concepts should be specified with the effect of failure identified.

- o DT&E / OT&E Plan. The aircraft DT&E/OT&E test plan should be reviewed to ensure it includes ground and flight tests necessary to safely and effectively develop the system.

- o Test Failures. Make T&E plans assuming failures--they are inevitable.

- o Multiservice Testing. When a new aircraft development program requires joint testing during OT&E, prior to Milestone II, the test plan should include the type of tests and resources required from other activities and Services.

o Traceability. The aircraft development and test program should be designed and scheduled in such a way that if trouble arises, the source of the trouble can be traced back through the lab tests and the analytical studies.

o Competitive Prototype Tests. When a competitive prototype test program is used, the aircraft should be compared on the basis of the performance of critical mission using both test and operational crews.

o Prototype Similarity To Development and Production Aircraft. A firm determination should be made of the degree of similarity of the winning prototype (in a competitive prototype program) to the development and production aircraft in order that test results derived from the prototype in the interim period prior to availability of the engineering development aircraft can be utilized most effectively.

o Prototype Tests. The prototype aircraft test data should be used to determine where emphasis should be placed in the engineering development program.

o Inlet / Engine / Nozzle Match. The aircraft test program should provide for early and adequate inlet/engine/nozzle match through a well planned test program with time programming for corrections.

o Subsystem Tests. There should be a balanced program for the aircraft subsystem tests.

o Propulsion System. If the aircraft is paced by the propulsion systems development, an early advanced development project for the propulsion may be appropriate for a new concept.

o EMI Testing. Full scale aircraft systems tests in an anechoic chamber are desirable for some aircraft.

o Parts Interchange. Early plans should provide for tests where theoretically identical parts, particularly in avionics, are interchanged to ensure that the aircraft systems can be maintained in readiness.

o Human Factors Demonstration. Ensure adequate demonstration of human factors is considered in the test plan.

o Military Preliminary Evaluation. Adequate resources should be scheduled for the aircraft Military Preliminary Evaluation (MPE) and a positive program should exist for the utilization of MPE information at the time of OT&E.

o User Participation. It is imperative that the operational command actively participate in the DT&E phase to ensure that the user needs are represented in the development of the system.

o Maintenance and Training Publications. The aircraft development program should provide for concurrent training of crews and for the preparation of draft technical manuals to be used by IOT&E maintenance and operating crews.

o R&D Completion Prior To IOT&E. The testing plans should ensure that before an aircraft system is subjected to IOT&E, the subsystems essential to the basic mission have completed R&D.

25.7.1.3 Full-Scale Development Phase

o Test Design. Test programs should be designed to have a high probability of identifying major deficiencies early, during the DT&E and IOT&E.

o Data for Alternate Scenarios. Maximize the utility of the test data gathered by careful attention to testing techniques; aircraft instrumentation; range instrumentation; and data collection, reduction and storage.

o Test Milestones. Development programs should be built around testing milestones, not calendar dates.

o Production Engineering Influence on R&D Hardware. Encourage that production philosophy and production techniques be brought into an early phase of the design process for R&D hardware to the maximum extent practical.

o Running Evaluation of Tests. Ensure that running evaluations of test are conducted. If it becomes clear that test objectives are unattainable or that additional samples will not change the test outcome, ensure procedures are established for terminating the test.

o Simulation. Analysis and simulation should be conducted, where practicable, before each phase of development flight testing.

o Avionics Mock-up. Encourage use of a complete avionics system installed in a mock-up of the appropriate section or sections of the aircraft.

o Escape Systems Testing. Ensure the aircrew escape system is thoroughly tested with particular attention to redundant features, such as pyrotechnic firing channels.

- Structural Testing. Assure that fatigue testing is conducted on early production airframes. Airframe production should be held to a low-rate until satisfactory progress is shown in these tests.

- Gun Firing Tests. All forms of ordnance, and especially those which create gases must be fired from the aircraft for external effects (blast and debris), internal effects (shock), and effects on the propulsion (inlet composition or distribution).

- Post Stall Characteristics. Special attention is warranted on the post stall test plans for DT&E and OT&E.

- Subsystem Performance History. During DT&E and IOT&E of aircraft, ensure a performance history of each subsystem of the aircraft will be kept.

- Flight Deficiency Reporting. Composition of flight deficiencies reporting by aircrews, particularly those pertaining to avionics, should be given special attention.

- Crew Limitations. Ensure aircrew limitations are included in the tests.

- Use of Operational Personnel. Recommend experienced operational personnel help in establishing measures of effectiveness and in other operational test planning. In conducting OT&E, use typical operational aircrews and support personnel.

- Role of the User. Ensure that users participate in the T&E phase so that their needs are represented in the development of the system concept and hardware.

- Crew Fatigue and System Effectiveness. In attack aircraft operational testing, and particularly in attack helicopter tests where vibration is a fatiguing factor, ascertain that the tests include a measure of degradation over time.

- Time Constraints on Crews. Detailed operational test plans should be evaluated to determine that the test-imposed conditions on the crew do not invalidate the applicability of the data so collected.

- Complete Basic DT&E Before Starting OT&E. Before the weapon system is subjected to IOT&E, all critical subsystems should have completed basic DT&E with significant problems solved.

- Realism in Testing. Ascertain that final DT&E system tests and IOT&E flight tests are representative of operational conditions.

o Test All Profiles and Modes. Tests should be conducted to evaluate all planned operational flight profiles and all primary and back-up, degraded operating modes.

o Update of Operational Test Plans. Ensure operational test plans are reviewed and updated as needed to make them relevant to evolving concepts.

o Conduct IOT&E Early. Ensure operational suitability tests are planned to attempt to identify operational deficiencies of new systems quickly so that fixes can be developed and tested before large scale production.

o Missile Launch Tests. Review the final position fix planned before launching inertial guided air-to-surface missiles.

o Mission Completion Success Probability. Mission completion success probability factors should be used to measure progress in the aircraft test program.

25.7.1.4 Full-Rate Production Phase

o Operational Test Realism. Ascertain operational testing is conducted under realistic conditions.

o Design OT&E For Less Than Optimal Condition. Structure the OT&E logistical support for simulated combat conditions.

o New Threat. Be alert to the need to extend the OT&E if a new threat shows up.

o Certification of Ordnance. Assure that ordnance to be delivered by an aircraft is certified for the aircraft.

o Inadvertent Influence of Test. OT&E plans should provide measures of ensuring that actions by observers and umpires do not unwittingly influence trial outcome.

o Deficiencies Discovered In-Service. Be aware that in-service operations of an aircraft system will surface deficiencies which extensive follow-on OT&E probably would not uncover.

o Lead The Fleet. Accelerated service test of a small quantity of early production aircraft is advisable during follow-on OT&E thereafter.

25.7.2 Missile Systems

25.7.2.1 Concept Exploration/Definition Phase

o Weapon System Interfaces. Consider significant weapon system interfaces, their test requirements and probable costs at the outset of the Concept Exploration/Definition Phase. Ensure that the program plan assembled before Milestone I includes an understanding of the basic test criteria and broad test plans for the whole program.

o Number of Test Missiles. Ensure that there is sufficient time and a sufficient number of test articles to support the program through its various phases. Compare the program requirements with past missile programs of generic similarity. If there is substantial difference, then adequate justification should be provided. The DT&E period on many programs has had to be extended as much as 50 percent.

o T&E Gap. A test and evaluation gap has been experienced in some missile programs between the time when testing with R&D hardware was completed and the time when follow-on operational suitability testing was initiated with production hardware.

o Feasibility Tests. Ensure experimental test evidence is available to indicate the feasibility of the concept and the availability of the technology for the system development.

o Evaluation of Conceptual and Validation Tests. Results of tests conducted during the Concept Exploration/Definition and the Concept and Demonstration/Validation phases, which most likely have been conducted as avionics brassboard, breadboard, or as modified existing hardware, should be evaluated with special attention.

o Multiservice Testing Plans. When a new missile development program requires multiservice testing during OT&E, the test plan should include the type of tests and resources required from other activities and services.

o Test Facilities and Instrumentation Requirements. Before Milestone I the test facilities and instrumentation requirements to conduct tests should be generally identified along with a tentative schedule of test activities.

25.7.2.2 Concept Demonstration/Validation Phase

o Establish Test Criteria. By the end of the Concept Demonstration/Validation phase, test criteria should be established so that there is no question as to what will constitute a successful test and what performance is expected.

o Human Factors. Ensure that the test plan includes adequate demonstration of human factors consideration.

o Instrumentation Diagnostic Capability and Compatibility. Instrumentation design with adequate diagnostic capability and compatibility in both DT&E and IOT&E phases is essential.

o Provisions for Test Failures. DT&E and OT&E plans should make provisions for the occurrence of failures.

o Integrated Test Plan. Assure an integrated system test plan that pre-establishes milestones and goals for easy measurement of program progress at a later time.

o Test and Evaluation Requirements. Ensure that the test and evaluation program requirements are firm before approving an R&E test program. Many missile programs have suffered severe cost impacts as a result of this deficiency. The test plan must include provisions to adequately test those portions of the operational envelope which stress the system including backup and degraded operational modes.

o Personnel Training Plans. Ensure that adequate training and certification plans for test personnel have been developed.

o T&E Reporting Format. Include a T&E reporting format in the program plan. Attention must be given to the reporting format in order to provide a consistent basis for test and evaluation throughout the program life cycle.

o Program-to-Program Crosstalk. Encourage program-to-program T&E crosstalk. Test and evaluation problems and their solutions as one program provide a valuable index of lessons learned and techniques for problem resolution on other programs.

o Status of T&E Offices. Ensure that Test and Evaluation offices have the same stature as other major elements, reporting to the program manager or director. It is important that the test and evaluation component of the system program office have organizational status and authority equal to configuration management, program control, system engineering, etc.

o Measurement of Actual Environments. Thorough measurements should be made to define and understand the actual environment in which the system components must live during the captive, launch and in-flight phases.

o Thoroughness of Laboratory Testing. Significant time and money will be saved if each component, each subsystem, and the full system are all tested as thoroughly as possible in the laboratory.

o Contract Form. The contract form can be extremely important to the T&E aspects. In one program, the contract gave the contractor full authority to determine the number of test missiles, and in another the contract incentive resulted in the contractor concentrating tests on one optimum profile to satisfy the incentive instead of developing the performance throughout important areas of the envelope.

o Participation of Operational Command. It is imperative that the operational command actively participate in the DT&E phase to ensure that the user needs are represented in the development of the system.

25.7.2.3 Full-Scale Development Phase

o Production Philosophy and Techniques. Encourage that production philosophy and production techniques be brought into an early phase of the design process for R&D hardware to the maximum extent practical. There are many missile programs in which the components were not qualified until the missile was well into production.

o Operational Flight Profiles. Tests should be conducted to evaluate all planned operational flight profiles and all primary and back-up degraded operating modes.

o Failure Isolation and Responsive Action. Does the system test plan provide for adequate instrumentation so that missile failures can be isolated and fixed before the next flight.

o Responsive Actions for Test Failures. Encourage a closed loop reporting and resolution process which assures that each test failure at every level is closed out by appropriate action, i.e., redesign, procurement, retest, etc.

o Plan Tests of Whole System. Plan tests of the whole system including proper phasing of the platform and supporting gear, the launcher, the missile, and the user's participation.

o Determination of Component Configuration. Conditions and component configuration during development tests should be determined by the primary objectives of that test. Whenever a non-operational configuration is dictated by early test requirements, tests should not be challenged by the fact that configuration is not operational.

o Testing of Software. Test and evaluation should ensure that software products are tested appropriately during each phase. Software has often been developed more as an add-on than as an integral part of the overall system. Software requirements need the same consideration as hardware requirements in the Concept Demonstration/Validation Phases.

o Range Safety Dry Runs. Ensure the test plan includes adequate test program/range safety dry runs. The government test ranges have to provide facilities to safely test many different projects.

o Assemblies/Subsystems Special Requirements.

- Seekers and tracking devices,
- Propulsion subsystems,
- Connectors and their related hardware,
- Lanyard assemblies, and
- Safing, arming, fuzing and other ordnance devices.

o Review of Air-To-Surface Missile Test Position Fixes. Review the final position fix planned before launching ASMs. There are instances in which the operational test of air launched missiles utilized artificial position fixes just prior to missile launch.

o Operator Limitations. Ensure operator limitations are included in the tests. Most tactical missiles, especially those used in close support, require visual acquisition of the target by the missile operator and/or an air/ground controller.

o Test Simulations and Dry Runs. Plan and use test simulations and dry runs. Dry runs should be conducted for each new phase of testing. Simulation and other laboratory or ground testing should be conducted to predict the specific test outcome. The "wet run" test should finally be run to verify the test objectives. Evaluation of the simulation versus the actual test results will help to refine the understanding of the system.

o Component Performance Records. Keep performance records on components. There are many examples in missiles programs which have required stock sweeps that are associated with flight failures and aging testing programs.

o Tracking of Test Data. Ensure the test program tracks data in a readily usable manner. Reliability and performance evaluations of a missile system should break down the missile's activity into at least the following phases:

- Pre-launch including captive carry reliability,
- Launch,
- In-flight, and
- Accuracy/fuzing.

o Updating of IOT&E Planning. Periodically update military preliminary evaluation (MPE) and IOT&E planning during the early R&D phase. Few missile system programs have had adequate user participation with the desirable continuity of personnel to minimize the problems of transition from DT&E to OT&E to deployment/utilization.

o Instrumentation Provisions in Production Missiles. Encourage built-in instrumentation provisions in production missiles.

o Constraints on Missile Operator. Detailed test plans should be evaluated to determine that the test imposed constraints on the missile operator do not invalidate the applicability of the data so collected.

o Problem Fixes Before Production. Ensure operational suitability tests identify operational deficiencies of new systems quickly so that fixes can be developed and tested before large scale production.

o Flight Tests Representative of Operations. Ascertain that final DT&E system tests and IOT&E flight tests are representative of operational flights. Some ballistic missile R&E programs have shown very high success rates in R&E flight test; however, when the early production systems were deployed, they exhibited a number of unsatisfactory characteristics such as poor alert reliability and poor operational test flight reliability.

25.7.2.4 Full Rate Production/Deployment Phase

o System Interfaces in Operational Test. Ensure the primary objective of an operational test is to obtain measurements on the overall performance of the weapon system when it is interfaced with those systems required to operationally use the weapons system.

o Realistic Conditions for Operational Testing. Ascertain operational testing is conducted under realistic combat conditions. This means that the offense/defense battle needs to be simulated in some fashion before the evaluation of the weapon system can be considered completed. Whether this exercise is conducted within a single service (as in the test of a surface-to-surface anti-tank missile against tanks) or between services (as in the test of an air-to-surface missile against tanks with anti-aircraft protection), the plans for such testing should be formulated as part of the system development plan.

o Testing of all Operational Modes. Assure the follow-on OT&E plan includes tests of any operational modes not previously tested in IOT&E. All launch modes, included degraded, backup modes, should be tested in the follow-on OT&E because the software interface with the production hardware system should be thoroughly evaluated, otherwise small, easy to fix problems might preclude launch.

o Extension of the OT&E for New Threats. Be alert to the need to extend the OT&E if a new threat shows up. Very few missile programs perform any kind of tests relatable to evaluating system performance against current threats, let alone new threats.

o "Lead-the-Fleet" Production Scheduling. "Lead-the-Fleet" missile scheduling and tests should be considered.

o Test Fixes. Test fixes resulting from earlier operational testing. Following initial operational tests which identify problem areas in missiles, Follow-on OT&E should be alert in these areas with the primary intent of investigating the adequacy of the fixes incorporated, particularly if the IOT&E did not run long enough to test the fixes.

o OT&E Feedback to Acceptance Testing. Ensure OT&E results are quickly fed back to influence early production acceptance testing. Production acceptance testing is probably the final means the government will normally have to ensure the product meets specifications. That early acceptance testing could be influenced favorably by a quick feedback from Follow-on OT&E to acceptance testing is exemplified by a current ASM program where production has reached peak rates and the OT&E has not been completed.

25.7.3 Command and Control Systems

25.7.3.1 Concept Exploration/Definition Phase

o Conceptual Test Philosophy. T&E planners must understand the nature of Command and Control systems early in the Concept Exploration/Definition Phase. In a complex Command and Control system, a total systems concept has to be developed at the beginning. Total systems life cycle must be analyzed so the necessary requirement for the design can be established.

o The Importance of Software Testing. Testers should recognize that software is a pacing item in Command and Control systems development.

o Software Test Scheduling - Contractors' Facilities. Provision should be made for inclusion of software T&E during each phase of C&C systems' acquisition. Availability of contractors' facilities should be considered.

o Evaluation of Exploratory Development Tests. Care should be exercised in evaluating results of tests conducted during exploratory development of Command and Control Systems. Results of tests conducted during exploratory development and which most likely have been conducted on brassboard, breadboard, or modified existing hardware should be evaluated with special attention.

o Feasibility Testing for Field Compilers. Early test planning should allow for simulation of the computer system to test for field use of compilers, where applicable.

o Evaluation of Test Plan Scheduling. Milestones should be event-oriented, not calendar-oriented.

o Type Personnel Needs - Effects on T&E. A mix of personnel with different backgrounds affecting T&E is required.

o Planning for Joint Service OT&E Before Milestone I. Joint Service Operation Test and Evaluation should be considered for Command and Control systems.

25.7.3.2 Concept Demonstration/Validation Phase

o Test Prototypes. In Command and Control Systems, prototypes must reasonably resemble final hardware configuration from a functional use standpoint. When high technical risk is present, development should be structured around the use of one or more test prototypes designed to prove the system concept under realistic operational conditions before proceeding to engineering development.

o Test Objectives - Critical Issues. In addition to addressing critical technical issues, T&E objectives during the Concept Demonstration/Validation Phase should address the functional issues of a Command and Control system.

o Real Time Software - Demonstration of "Application Patches". Tests of real time Command and Control systems should include demonstrations of interfaces whereby locally generated application patches are brought into being.

o Independent Software Test-User Group. An independent test-user software group is needed during early software qualification testing.

o System Interfaces. Critical attention should be devoted to testing interfaces with other C&C systems and to interfaces between subsystems. Particular attention should be devoted to interfaces with other C&C systems and to the interfaces between sensors (e.g., radars), communications systems (e.g., modems), and the specific processors (e.g., CPU). Interface with information processing C&C systems must also address data element and code standardization problems if data is to be processed on-line.

o Human Factors. In a C&C system human factors must be considered from the earliest prototype designs and testing provided. Testing should be conducted to determine the most efficient arrangement of equipment from the human factor standpoint, e.g., displays should be arranged so as to be viewed from an optimum angle whenever possible; adequate maneuvering room within the installation constraints should be allowed considering the number of personnel normally manning the facility; and console-mounted controls should be so designed and located as to facilitate operation, minimize fatigue and avoid confusion.

o Degraded Operations Testing. When the expected operational environment of a C&C system suggests that the system may be operated under less than finely tuned conditions, tests should be designed to allow for performance measurements under degraded conditions.

o Test Bed. The use of a test bed for study and experimentation with new C&C systems is needed early in the Concept Demonstration/Validation Phase.

o Software-Hardware Interfaces. The software-hardware interfaces with all operational back-up modes to a new C&C system should be tested early in the program.

o Reproducible Tests. Test plans should contain a method for allowing full-load message inputs while maintaining reproducible test conditions.

o Cost-Effectiveness. Field test data is needed during the Concept Demonstration/Validation Phase for input to cost effectiveness analyses of C&C systems.

25.7.3.3 Full-Scale Development Phase

o Acquisition Strategy. The acquisition strategy for the system should:

- Allow for sufficient time between the planned end of demonstration testing and major procurement (as opposed to limited procurement) decisions so that there is a flexibility for modification of plans which may be required during the test phases of the program. For instance, because insufficient time was allowed for testing one recent C&C system, the program and the contract had to be modified and renegotiated.

- Be evaluated relative to constraints imposed.

- Ensure that sufficient dollars are available not only to conduct the planned T&E but to allow for the additional T&E which is always required due to failures, design changes, etc.

o Problem Indications. It is important to establish an early detection scheme for management to determine when a program is becoming ill.

o Impact of Software Failures. Prior to any production release, the impact of software failures on overall system performance parameters must be considered.

o Critical Issues. IOT&E should provide the answers to some critical issues peculiar to C&C systems. Some of the critical issues that OT&E of Command and Control systems should answer are:

- Is system mission reaction time a significant improvement over present systems?

- Is a back-up mode provided for use when either airborne or ground system exhibits a failure?

- Can the system be transported as operationally required by organic transport? (Consider ground, air and amphibious requirements).

- Is there a special requirement for site preparation? (For example, survey, antenna siting).

- Can the system be erected and dismantled in times specified? Are these times realistic?

- Does relocation affect system alignment?

- Does system provide for operation during maintenance?

- Can maintenance be performed on site on non-shelterized exposed subsystems during adverse weather conditions, e.g., radars?

o Displays. The display subsystems of a C&C system should provide an essential function to the user. Displays are key subsystems of a Command and Control system. They provide the link that couples the operator to the rest of the system and are therefore often critical to its success.

o Pilot Test. A pilot test should be conducted prior to IOT&E so that sufficient time is available to make the necessary changes to the IOT&E as dictated by the results of the pilot test.

o Publications and Manuals. It is imperative that all system publications and manuals be completed, reviewed and selectively tested under operational conditions prior to the beginning of overall system suitability testing.

o Power Sources. Mobile prime power sources are usually provided as GFE and can be a problem area in testing C&C systems.

o IOT&E Reliability Data. IOT&E can provide valuable data on the operational reliability of a C&C system which cannot be obtained through DT&E.

o Subsystem Tests. Every major subsystem of a C&C system should have a successful DT&E prior to beginning of overall system operational testing.

o Communications. C&C systems must be tested in the appropriate electromagnetic environment to determine performance of its communications system.

o Maintenance. In IOT&E, maintenance should include: A measurement of the adequacy of the maintenance levels and the maintenance practices; an assessment of the impact that the maintenance plan has on the operational reliability; the accessibility of the major components of the system for field maintenance, e.g., are cables and connectors installed so as to facilitate access; and verification that the software design for maintenance and diagnostic routines and procedures are adequate and that the software can be modified to accommodate functional changes.

o Continuity of Operations. IOT&E should provide for an impact assessment of the failure of any subsystem element of a C&C system on overall mission effectiveness.

o Imitative Deception. IOT&E should provide for tests to assess the susceptibility of the data links of a C&C system to imitative deception.

o Demonstration of Procedures. Test plans should include a procedural demonstration whereby the tested C&C system works in conjunction with other systems.

o Government Furnished Equipment and Facilities. T&E should be concerned about the availability of GFE equipment as specified in the proposed contract.

o User Participation in T&E. The varying needs of the user for a C&C system make it mandatory that he participate in all phases of T&E.

25.7.3.4 Full Rate Production/Deployment Phase

o First Article Testing. Conduct first article testing. The preproduction, first article, testing and evaluation should be designed and conducted to: (1) confirm the adequacy of the equipment to meet specified performance requirements; (2) confirm the adequacy of the software not only to meet current user needs but also to accommodate changing needs; and (3) determine failure modes and rates of the total integrated system. This activity should be followed by FOT&E.

o Test Planners and Evaluators. Use the IOT&E personnel in the Follow-on OT&E program. The planners and evaluators for the OT&E of the production system can do a better job if they are initially involved in planning and conducting the IOT&E.

25.7.4 Ship Systems

25.7.4.1 Concept Exploration/Definition Phase

o Test and Evaluation Master Plan. Prior to Milestone I, sufficient materiel should be generated to allow for an evaluation of the overall T&E program.

o Test Objectives and Critical Issues. In evaluating the initial test concept, it is important that the test objectives during the time from Milestone I to Milestone II address the major critical issues, especially technological issues.

o OT&E Phasing. In evaluating test plans, look favorably on phasing where the OT&E is run in parallel with continued DT&E.

o Test Facilities and Instrumentation Required. Before Milestone I, the test facilities and instrumentation requirements to conduct developmental and operational tests should be identified, along with a tentative schedule of test activities.

o Multiple Approach To Weapon System Development. Whenever possible, the weapon system concept should not be predicated on the successful development of a single hardware or software approach in the various critical subsystems (unless it has been previously demonstrated adequately).

o Comparison of New Versus Old System. The procedure for examining the relative performance of new or modified systems versus old should be indicated in the T&E plan.

o Test Support Facilities. The phasing of test support facilities must be carefully planned, with some schedule flexibility to cover late delivery and other unforeseen problems.

o Fleet Operating Force Requirements. The requirement for fleet operating forces for DT&E or OT&E should be assessed early in the program, and a specific commitment made as to the types of units to be employed.

o Mission Related Measures of Effectiveness. During the Concept Exploration/Definition Phase of the acquisition of a new class of ship, a study effort should be commenced jointly by the CNO and COMOPTEVFOR to establish mission-related measures of effectiveness which may be expressed in numerical fashion and which may later be made the subject of OT&E to determine how closely the new ship system meets the operational need for which it was conceived.

o Ship T&E Management. The management of ship T&E should ensure that test requirements are necessary and consistent relative to systems/subsystem aspects and that the necessary testing is coordinated so that test redundancy does not become a problem.

o T&E of Large, Integrally-Constructed Systems. Major subsystems should be proven feasible prior to firm commitment to a detailed hull design.

25.7.4.2 Concept Demonstration/Validation Phase

o Authentication of Human Factors Concepts. T&E should authenticate the human factors concepts embodied in the proposed systems design, examining questions of safety, comfort, appropriateness of man-machine interfaces, as well as the numbers and skill levels of the personnel required.

o Acquisition Strategy. The acquisition strategy for a ship and its subsystems should allow for a sufficient time between the planned end of demonstration testing and major procurement decisions of government furnished equipment so that there is a flexibility for modification of plans which may be required during the test phases of the program.

o Evaluation of Results of Exploratory Testing. Results of tests conducted during exploratory development and which most likely have been conducted on brassboards, breadboards, or modified existing hardware should be carefully evaluated.

o Software Testing. In view of increased dependence upon computers in ship management and tactical operation, software testing must be exceptionally thorough, and integrated software testing must begin as early as possible.

o New Hull Forms. When a new type of ship involves a radical departure from the conventional hull form, extensive prototype testing prior to further commitment to the new hull form should be required.

o Effects of Hull and Propulsion on Mission Capability. The predicted effects of the proven hull and propulsion system design on the performance of the ship's critical system should be determined.

o Advances in Propulsion. Demonstration of the use of new propulsion systems should be conducted prior to making the decision to commit the propulsion systems to the ship in question.

o Propulsion Systems in Other Classes. When an engine to be used in the propulsion system of a new ship is already performing satisfactorily in another ship, this is not to be taken as an indication that shortcuts can be taken in propulsion system DT&E, or that no problems will be encountered.

o IOT&E of Shipboard Gun Systems. Operational tests of shipboard gun systems should simulate the stress, exposure time and other conditions of battle so that the suitability of the weapon can be evaluated in total.

o Targets for Anti-Aircraft Warfare (AAW) IOT&E. Operational test of shipboard AAW weapons demands the use of targets which realistically simulate the present day threat.

o Waivers to T&E of Ship Systems. Waivers to T&E of pre-production models of a system in order to speed up production and delivery should be made only after consideration of all costs and benefits of the waiver, including those not associated with the contract.

o Environment Effects on Sonar Domes. Environmental effects on sonar domes and their self-noise should be tested and evaluated before the domes are accepted as part of the sonar system.

o Hull/Machinery Testing By Computer Simulation. In DT&E ships, there will be cases where the best means to conduct evaluations of particular hull and machinery capabilities is through dynamic analysis using computer simulation, with later validation of the simulation by actual test.

o Operational Reliability. IOT&E should provide valuable data on the operational reliability of ship weapon systems which cannot be obtained through DT&E.

25.7.4.3 Full Scale Development Phase

o Initial or Pilot Phase of IOT&E. Before any operational tests for demonstration of operational suitability and effectiveness are conducted, an initial or pilot test should be conducted.

o Identify Critical Subsystems. In the planning for the IOT&E of a ship system, the critical subsystems with respect to mission performance should be identified.

o Reliability of Critical Systems. T&E should determine the expected reliability at sea of systems critical to the ship's mobility and primary and major secondary tasks.

o Consistency in Test Objectives. There are various phases of testing of a ship system. One should ensure that the objectives of one phase are not inconsistent with the objectives of the other phases.

o Single Screw Ships. T&E of the propulsion systems of ships with a single screw should be especially rigorous to determine failure rates, maintenance and repair alternatives.

o Problems Associated With New Hulls. Whenever a new hull is incorporated into the ship design, a test and evaluation of this hull should be conducted prior to the full-rate production and incorporation of the major weapons subsystems.

25.7.4.4 Full-Rate Production Phase

o Design of Ship FOT&E. In the testing program of a ship system, it should be recognized that although it may be designated as a special purpose ship, it will in most cases be used in a general purpose role as well.

o Operational Testing During Shakedown Periods. The time period for OT&E of a ship can be used more efficiently if full advantage is taken of the periods immediately after the ship is delivered to the Navy.

o Fleet Operations in FOT&E. A great deal of information on the operational effectiveness of a ship can be obtained from standard fleet operations through well designed information collection, processing, and analysis procedures.

o Ship ASW OT&E PLanning. In planning OT&E of shipboard systems, it is important to recognize the difficulty of achieving realism, perhaps more so than in other areas of naval warfare.

o Variable Depth Sonar OT&E. The behavior of towed bodies of variable depth sonar systems and towed arrays should be tested and evaluated under all ship maneuvers and speeds likely to be encountered in combat.

o Ship Self-Noise Tests. The magnetic and acoustic signatures of a ship can be tested accurately only after it is completed.

o Effect of Major ECM on Ship Capability. The FOT&E of a ship should include tests of the effectiveness of the ship when subjected to major ECM.

o Ship System Survivability. Operational Test and Evaluation of modern ships should provide for the assessment of their ability to survive and continue to fight when subjected to battle damage.

o Interlocks. Shipboard electronic systems are designed with interlock switches that open electrical circuits for safety reasons when the equipment cabinets are opened. OT&E should be able to detect over-design as well as minimum design adequacy of the interlock systems.

o Intra-Ship Communication. In the conduct of lead ship trials and evaluations, particular attention should be given to the operational impact resulting from absence, by design, of intra-ship communications circuits and stations from important operating locations.

25.7.5 Surface Vehicle Systems

25.7.5.1 Concept Exploration/Definition Phase

o Preparation of Test Plans. It is necessary that a detailed evaluation criteria be established which includes all items that are to be tested.

o Validation Test Plans. Prior to Milestone I, a plan should be prepared for an evaluation of the overall T&E program. As part of this, a detailed test and evaluation plan for those tests to be conducted prior to Milestone II to validate the concept and hardware approach to the vehicle system should be developed. The objective of the validation test plan is to fully evaluate the performance characteristics of the new concept vehicle. This test plan cannot be developed, of course, until the performance characteristics are defined.

o Performance Characteristics Range. Stated performance characteristics derived from studies should be measured early in the program. Unrealistic performance requirements can lead to false starts and costly delays.

o Operating Degradation. System performance degrades under field conditions. Anticipated degradation must be considered during test and evaluation. When a system must operate at peak performance during DT/OT to meet the specified requirements it then will likely perform at a lesser level when operated in the field.

o Test Personnel. The Test Director and/or key members of the test planning group within the project office should have significant T&E experience.

o Design Reviews. T&E factors and experience must influence the system design. The application of knowledge derived from past experience can be a major asset in arriving at a sound system design.

o Prototype Vehicles. When high technical risk is present, development should be structured around the use of one or more prototype vehicles designed to prove the system concept under realistic operational conditions before proceeding to engineering development.

o Test Facilities and Scheduling. Before Milestone I, test range and resource requirements to conduct validation tests should be identified along with a tentative schedule of test activities.

25.7.5.2 Concept Demonstration/Validation Phase

o Vulnerability. The vulnerability of vehicles should be estimated on the basis of testing.

o Gun and Ammunition Performance. Gun and ammunition development should be considered a part of overall tank system development. When a new gun tube, or one which has not previously been mounted on a tank chassis, is being evaluated, all ammunition types (including missiles) planned for use in that system should be test fired under simulated operational conditions.

o Increased Complexity. The addition of new capabilities to an existing system or system type will generally increase complexity of the system, and therefore increase the types and amount of testing required and the time to perform these tests.

o Component Interfaces. Prior to assembly in a prototype system, component subsystems should be assembled in a mockup and verified for physical fit, human factors considerations, interface compatibility, and electrical and mechanical compatibility.

o Determination of Test Conditions. Test conditions during validation should be determined by the primary objectives of that test, rather than by more general considerations of realism.

o Test Plan Development. The test plan developed by this point should be in nearly final form, and include as a minimum:

- A description of requirements,
- The facilities needed to make evaluations,
- The schedule of evaluations and facilities,
- The reporting procedure, the objective of which is to communicate test results in an understandable format to all program echelons,
- The Test and Evaluation Guidelines, and
- A further refinement of the cost estimates which were initiated during the conceptual phase.

o Demonstration Tests. Demonstration tests should show satisfactory meeting of success criteria which are meaningful in terms of operational usage. In designing contractually required demonstration tests, upon whose outcome may depend large incentive payments, or even program continuation, it is essential to specify broader success criteria than simply hit or miss in a single given scenario.

o Reliability Testing. Reliability testing should be performed on component and subsystem assemblies prior to testing of the complete vehicle system. Prior to full system testing viable component and subsystem tests should be conducted.

o Human Factors. In evaluating ground vehicles, human factors should be considered at all stages starting with the design of the prototype.

o Test Plan Scheduling. Test plan scheduling should be tied to event milestones rather than to the calendar. In evaluating the adequacy of the scheduling as given by test plans, it is important that milestones be tied to the major events of the weapon system (meeting stated requirements) and not the calendar.

o Test Failures. The T&E schedule should be sufficiently flexible to accommodate failures and correction of problems which have been identified.

25.7.5.3 Full-Scale Development Phase

o Planning the Operational Test. Operational testing should be cost effective and provide meaningful results.

o Pilot and Dry Run Tests. A scheduled series of tests should be preceded by a dry run which verifies that the desired data will be obtained.

o Comparison Testing. The test program should include a detailed comparison of the characteristics of a new vehicle system with those of existing systems, alternate vehicle system concepts (if applicable), and those of any system(s) being replaced.

o Simulations. Simulation techniques and equipment should be utilized to enhance data collection. Creation of histograms for each test course provides a record of conditions experienced by the vehicle during testing. Use of a chassis dynamometer can produce additional driveline endurance testing with more complete instrumentation coverage.

o Environmental Testing. Ground vehicles should be tested in environmental conditions and situations comparable to those in which they will be expected to perform.

o System Vulnerability. For combat vehicles, some estimate of vulnerability to battle damage should be made.

o Design Criteria Verification. Subsystem design criteria should be compared with actual characteristics.

o Electromagnetic Testing. Vehicle testing should include electromagnetic testing.

o System Strength Testing. In evaluating ground vehicles, early testing should verify intrinsic strength. This implies operation with maximum anticipated loading, including trailed loads at maximum speeds and over worst case grades, secondary roads, and cross-country conditions for which the vehicle was developed or procured. This test is intended to identify deficient areas of design, not to break the machinery.

o Component Compatibility. Component compatibility should be checked through the duration of the test sequence.

- Human Interface. Critiques of good and bad features of the vehicle should be made early in the prototype stage, while adequate time remains to make any indicated changes.

- Serviceability Testing. Ground vehicles should be tested and evaluated to determine the relative ease of serviceability, particularly with high frequency operations.

- Experienced User Critique. Ground vehicle user opinions should be obtained early in the development program.

- Troubleshooting During Tests. Provisions should be made to identify subsystem failure causes. Subsystems may exhibit failures during testing. Adequate provisions should be made to permit troubleshooting and identification of defective components and inadequate design.

25.7.5.4 Full-Rate Production/Deployment Phase

- Performance and Reliability Testing. The production first-article testing should verify the performance of the vehicle system and determine the degradation, failure modes, and failure rates.

- Lead-the-Fleet Testing. At least one production prototype or initial production model vehicle should be allocated in intensive testing so as to accumulate very high operating time in a short period.

- User Evaluation. User-reported shortcomings should be followed up to determine problem areas requiring correction.

APPENDIX A

ABBREVIATIONS AND ACRONYMS

AAE	Army Acquisition Executive
ADATS	Army Development and Acquisition Threat Simulators
ADM	Acquisition Decision Memorandum
AFOTEC	Air Force Operational Test & Evaluation Center
AFSC	Air Force Systems Command
AMC	Army Materiel Command
AMARC	Army Material Acquisition Review Committee
AMSAA	Army Materiel Systems Analysis Activity
ATE	Automatic Test Equipment
BIT	Built-In Test
C^2	Command and Control
C^3I	Command, Control, Communications, Intelligence
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CDS	Congressional Data Sheets
CDV	Concept Demonstration / Validation Phase
CED	Concept Exploration / Definition Phase
CLIN	Contract Line Item Number
CNP	Candidate Nomination Proposal
COEA	Cost and Operational Effectiveness Analysis
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
CSC	Computer Software Component
DA	Developing Agency (Navy)
CSCI	Computer Software Configuration Item
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DCP	Decision Coordinating Paper
DDDRE(T&E)	Deputy Director, Defense Research & Engineering (Test & Evaluation)
DLT	Design Limit Test
DVAL	Data Link Vulnerability Analysis
DPESO	DOD Product Engineering Services Office
DOT&E	Director, Operational Test and Evaluation

DOE	Department of Energy
DRB	Defense Resources Board
DT	Development Test
DT&E	Development Test & Evaluation
EA	Evolutionary Acquisition
ECM	Electronic Countermeasures
ECR	Engineering Change Review
EDT	Engineering Design Test
ERAM	Extended Range Anti-armor Munition
ESM	Electronic Support Measures
EW	Electronic Warfare
FCA	Functional Configuration Audit
FDT&E	Force Development Tests and Experimentation
FOT&E	Follow-on Test and Evaluation
FORSCOM	Forces Command
FQR	Formal Qualification Review
FSD	Full-Scale Development Phase
FWE	Foreign Weapons Evaluation
FYTP	Five Year Test Program
GPMO	Government Program Management Office
IEP	Independent Evaluation Plan
IFPP	Information for Proposal Preparation
ILS	Integrated Logistics Support
ILSMT	Integrated Logistic Support Management Team
ILSP	Integrated Logistics Support Plan
IOC	Initial Operating Capability
IOT&E	Initial Operational Test & Evaluation
IRA	Industrial Resource Analysis
ITP	Integrated Test Plan
IV&V	Independent Verification and Validation
JLF	Joint Live Fire
JRD	Joint Requirements Document
JT&E	Joint Test and Evaluation

LFT	Live Fire Test
LRIP	Low Rate Initial Production
MAA	Mission Area Analysis
MCCR	Mission Critical Computer Resources
MCOTEA	Marine Corps Operational Test & Evaluation Activity
MMOU	Multinational Memorandum of Understanding
MNS	Mission Needs Statement
MOE	Measure of Effectiveness
MOU	Memorandum of Understanding
MS	Milestone
MRTFB	Major Range and Test Facility Base
NAPMA	North Atlantic Program Management Agency
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NBC	Nuclear, Biological, and Chemical
NDCP	Navy Decision Coordinating Paper
NDI	Nondevelopment Item
OPNAV	Operational Navy
OPEVAL	Operational Evaluation
OPSEC	Operations Security
OPTEVFOR	Operational Test & Evaluation Force
OR	Operational Requirement
ORMAS/TE	Operational Resource Mgmt Assessment System for T&E
OT	Operational Test
OTA	Operational Test Agency
OTD	Operational Test Director
OT&E	Operational Test & Evaluation
OTEA	Operational Test & Evaluation Agency
OTO	Operational Test Organization
OTP	Outline Test Plan
OSD	Office of the Secretary of Defense
P^3I	Preplanned Product Improvements
PAT&E	Production Acceptance Test and Evaluation

PCA	Physical Configuration Audit
PCO	Primary Contracting Officer
PDR	Preliminary Design Review
PDSS	Post-Deployment Software Support
PMO	Program Management Office
POM	Program Objectives Memorandum
PPBS	Planning, Programming, and Budgeting System
PPQT	Preproduction Qualification Tests
PRESINSURV	President of the Boards of Inspection and Survey
PRR	Production Readiness Review
QOT&E	Qualification Operational Test and Evaluation
RAM	Reliability, Availability, and Maintainability
RDT	Reliability Development Testing
RDT&E	Research, Development, Test & Evaluation
RFP	Request for Proposal
ROC	Required Operational Capability
SAR	Selected Acquisition Report
SQA	Software Quality Assurance
SECARMY	Secretary of the Army
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SSR	Software Specification Review
SEF	Stability Enhancement Function
SIS	Stall Inhibit System
SON	Statement of Operational Need
SOW	Statement of Work
SPO	System Program Office
SCP	System Concept Paper
SDR	System Design Review
SEMP	System Engineering Management Plan
SRR	Systems requirements Review
STP	Software Test Plan
T&E	Test & Evaluation
TAAF	Test, Analyze and Fix

PCA	Physical Configuration Audit
PCO	Primary Contracting Officer
PDR	Preliminary Design Review
PDSS	Post-Deployment Software Support
PMO	Program Management Office
POM	Program Objectives Memorandum
PPBS	Planning, Programming, and Budgeting System
PPQT	Preproduction Qualification Tests
PRESINSURV	President of the Boards of Inspection and Survey
PRR	Production Readiness Review
QOT&E	Qualification Operational Test and Evaluation
RAM	Reliability, Availability, and Maintainability
RDT	Reliability Development Testing
RDT&E	Research, Development, Test & Evaluation
RFP	Request for Proposal
ROC	Required Operational Capability
SAR	Selected Acquisition Report
SQA	Software Quality Assurance
SECARMY	Secretary of the Army
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SSR	Software Specification Review
SEF	Stability Enhancement Function
SIS	Stall Inhibit System
SON	Statement of Operational Need
SOW	Statement of Work
SPO	System Program Office
SCP	System Concept Paper
SDR	System Design Review
SEMP	System Engineering Management Plan
SRR	Systems requirements Review
STP	Software Test Plan
T&E	Test & Evaluation
TAAF	Test, Analyze and Fix

TEAM	Test, Evaluation, Analysis, and Modeling
TEC	Test and Evaluation Committee
TECG	T&E Coordinating Group
TECOM	Test and Evaluation Command
TEMP	Test and Evaluation Master Plan
TIWG	Test Integrated Working Group
TMC	Test Management Council
TPO	Test Program Outline
TPWG	Test Planning Working Group
TRMS	TRADOC Resource Management System
TRADOC	Training and Doctrine Command
TRR	Test Readiness Review
TSARC	Test Schedule and Review Committee
US D(A)	Under Secretary of Defense (Acquisition)

APPENDIX B
DOD GLOSSARY OF
TEST TERMINOLOGY

ACCEPTANCE TRIALS - Trials and material inspection conducted underway by the trail board for ships constructed in a private shipyard to determine suitability for acceptance of a ship.

ACCRUED EXPENDITURES - Costs incurred during a given period representing liabilities incurred for goods and services received, other assets acquired, and performance accepted, whether or not payment has been made.

ACQUISITION - The process consisting of planning, designing, producing, and distributing a weapon system/equipment. Acquisition in this sense includes the conceptual, validation, full-scale development, production, and deployment/operational phases of the weapon systems/equipment project. For those weapon systems/equipments not being procured by a project manager, it encompasses the entire process from inception of the requirement through the operational phase.

ACQUISITION CATEGORY (ACAT) - One of four acquisition categories established by CNO which govern acquisition procedures and responsibilities and assign respective decision authority levels.

ACQUISITION RISK - The change that some elements of an acquisition program produces an unintended result with adverse effect on system effectiveness, suitability, cost, or availability for deployment.

ADVANCED DEVELOPMENT (Budget Category 6.3) - Includes all projects which have moved into the development of hardware for test.

AGENCY COMPONENT - A major organizational subdivision of an agency. For example: the Army, Navy, Air Force, and Defense Supply Agency are agency components of the Department of Defense. The Federal Aviation, Urban Mass Transportation, and the Federal Highway Administrations are agency components of the Department of Transportation.

ALLOCATION - An authorization by a designated official of a component of the Department of Defense making funds available within a prescribed amount to an operating agency for the purpose of making allotments; i.e., the first subdivision of an apportionment.

ANALYSIS - The qualitative and/or quantified evaluation of information requiring technical knowledge and judgement.

APPORTIONMENT - A determination by the Office of Management and Budget as to the amount of obligations which may be incurred when the nature of the work involved prevents the preparation of definitive requirements, specifications, or cost data. Sometimes called letter of intent.

AUTHORIZATION - Basic substantive legislation enacted by Congress which sets up a Federal program or agency either indefinitely or for a given period of time. Such legislation sometimes sets limits on the amount that can subsequently be appropriated, but does not usually provide budget authority.

AUTOMATIC TEST EQUIPMENT (ATE) - An equipment that is designed to automatically conduct analysis of functional or static parameters and to evaluate the degree of performance degradation and perform fault isolation of unit malfunctions.

BASELINE, APPROVED - The combination of approved program schedule, configuration, performance characteristics, acquisition, strategy, and other business aspects which constitute the variables reflected in either the appropriate acquisition milestone approval for that acquisition category or as reflected in the latest approved program management proposal action.

BRASSBOARD CONFIGURATION - An experimental device (or group of devices) used to determine feasibility and to develop technical and operational data. It will normally be a model sufficiently hardened for use outside of laboratory environments to demonstrate the technical and operational principles of immediate interest. It may resemble the end item but is not intended for use as the end item.

BREADBOARD CONFIGURATION - An experimental device (or group of devices) used to determine feasibility and to develop technical data. It will normally be configured only for laboratory use to demonstrate the technical principles of immediate interest. It may not resemble the end item and is not intended for use as the projected end item.

BUDGET - A planned program for a fiscal period in terms of (a) estimated costs, obligations and expenditures, (b) source of funds for financing, including reimbursements anticipated and other resources to be applied, and (c) explanatory and workload data on the projected programs and activities.

CONCEPT EVALUATION PROGRAM - A specifically funded Army innovative testing program. CEP's provide commanders and combat developers a quick reaction and simplified process to resolve combat development, doctrinal, and training issues in addition to solidifying combat development requirements and supporting early milestone decisions. Also, the CEP is used to provide an experimental data base for requirements documents and to expedite the materiel acquisition process; however, CEP's are not to be used as the primary tests to support decision review production decisions. CEP may be conducted at any time to support the CE process. Issues satisfied during the conduct of a CEP need not be examined during formal OT to minimize testing. Data from CEP's may be used as another source for preparation of the IER.

CONTINUOUS COMPREHENSIVE EVALUATION (C2E) - A continuous process extending from concept definition through deployment which evaluates the operational effectiveness and suitability of a system by analysis of all available data.

COMBAT SYSTEM - The equipment, computer programs, people and documentation organic to the accomplishment of the mission of an aircraft, surface ship, or submarine; excludes the structure, material, propulsion, power and auxiliary equipment, transmissions and propulsion, fuels and control systems, and silencing inherent in the construction and operation of aircraft, surface ships and submarines.

CONFIGURATION MANAGEMENT - A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, and (3) record and report change processing and implementation status.

CONTRACT - An agreement, enforceable by law, between two or more competent parties, to do or not to do something not prohibited by law, for a legal consideration.

CONTRACTOR SUPPORT - An arrangement during initial development or production of end-items whereby a contractor furnished required material and maintenance of an end-item or system pending assumption of supply by the military service.

COST OPERATIONAL EFFECTIVENESS ANALYSIS - A method of examining alternative means of accomplishing a desired military objective/mission for the purpose of selecting weapons and forces which will provide the greatest military effectiveness for the cost.

CRITICAL ISSUES - Those aspects of a system's capability either operational, technical, or other, that must be questioned before a system's overall worth can be estimated, and that are of primary importance to the decision authority in reaching a decision to allow the system to advance into the next acquisition phase.

DATA SYSTEM - Combinations of personnel efforts, forms, formats, instructions, procedures, data elements and related data codes, communications facilities, and automatic data processing equipment, which provide an organized and interconnected means, either automated, manual, or a mixture of these for recording, collecting, processing and communicating data.

DEFENSE ACQUISITION EXECUTIVE (DAE) - The principal advisor to the Secretary of Defense on all matters pertaining to the Department of Defense Acquisition System. The Under Secretary of Defense for Acquisition (US D(A)) is the DAE and the Defense Procurement Executive.

DEPARTMENT OF DEFENSE ACQUISITION SYSTEM - A single uniform system whereby all equipment, facilities, and services are planned, designed, developed, acquired, maintained, and disposed of within the Department of Defense. the system entails establishing policies and practices that govern acquisitions, determining and prioritizing resource requirements, directing and controlling the process, contracting, and reporting to Congress.

DESIGNATED ACQUISITION PROGRAM - Program designated by the Army Acquisition Executive for DRB milestone review.

DESIGNATED OPERATIONAL TESTER - The Major Command or Army Special Staff Agency delegated authority to conduct specific OT. Designated operational testers conduct the operational test of assigned systems and will normally prepare the evaluation of that system. The actual operational test and/or evaluation is usually accomplished by a subordinate element of the designated operational tester. The designated operational tester can be TRADOC, USAISC, TSG, INSCOM, COE, or another designated command or agency.

DEMONSTRATION AND VALIDATION DECISION - Milestone I decision by which the SECDEF reaffirms the mission need and approves one or more selected alternatives for competitive demonstration and validation.

DEVELOPING AGENCY (DA) - The Systems Command or CNM-designated project manager assigned responsibility for the development, test and evaluation of a weapon system, subsystem or item of equipment.

DEVELOPER EVALUATION - The developer's evaluation addresses all aspects of the system to include technical performance, operational effectiveness, and operational suitability cost and schedule.

DEVELOPMENT TEST - A technical test conducted post-MS I, pre-MS II to provide data on safety, the achievability of critical system technical characteristics, refinement and ruggedization of hardware configurations, and determination of technical risks. This testing is performed on components, subsystems, materiel improvement, nondevelopment items (NDI), hardware-software integration and related software. DT includes the testing of compatibility and interoperability with existing or planned equipment and systems and the system effects caused by natural and induced environmental conditions during the development phases of the materiel acquisition process. Program funding category 6.3.

ENGINEERING CHANGE PROPOSAL - Proposal to change design or engineering features of materiel under development or production. Includes proposed engineering change and documentation by which the change is described and suggested.

ENGINEERING DEVELOPMENT - RDTE funding category that includes development programs being engineered for Service use, but not yet approved for procurement or operation.

EFFECTIVENESS - The performance or output received from an approach or a program. Ideally, it is a quantitative measure which can be used to evaluate the level of performance in relation to some standard, set of criteria, or end objective.

ENGINEERING CHANGE - An alteration in the physical or functional characteristics of a system or item delivered, to be delivered, or under development, after establishment of such characteristics.

ENGINEERING DEVELOPMENT (Budget Category 6.4) - Includes those projects in full-scale development of Service use but which have not yet received approval for production or had production funds included in the DoD budget submission for the budget or subsequent fiscal year.

EVALUATION CRITERIA - Standards by which achievement of required technical and operational effectiveness/suitability characteristics, or resolution of technical or operational issues, may be evaluated. At Milestone I and II, evaluation criteria should include quantitative thresholds for the IOC system. At Milestone III and beyond (or IOC, whichever occurs first), evaluation criteria should include quantitative thresholds for the mature system. If system maturity is greater than 2 years beyond IOC, intermediate evaluation criteria, appropriately time-lined, must also be provided.

FIVE-YEAR DEFENSE PROGRAM - The official document which summarizes the SECDEF-approved plans and programs for the Department of Defense. It is published at least once annually.

FOLLOW-ON OPERATIONAL TEST AND EVALUATION - Test and evaluation conducted subsequent to a full production decision to obtain information lacking from previous Operational Test and Evaluation, or to verify correction of materiel, training, or concept deficiencies.

FOLLOW-ON PRODUCTION TEST - A technical test conducted subsequent to a full production decision on initial production and mass production models to determine production conformance for quality assurance purposes. Program funding category - Procurement.

GOAL - Something to which one aspires for a program, or, a point aimed at for achievement.

INTEGRATED LOGISTIC SUPPORT (ILS) - A disciplined, unified, and iterative approach to the management and technical activities necessary to : (a) integrate support considerations into system and equipment design; (b) develop support requirements that are related consistently to readiness objectives, to design, and to each other, (c) acquire the required support; and (d) provide the required support during the operational phase at minimum cost.

INTEROPERABILITY - The ability of systems, units, or forces to provide services to, and accept services from, other systems, units or forces, and to use the services so exchanged to enable them to operate together effectively.

INDEPENDENT EVALUATION REPORT - A report that provides an assessment of item or system operational effectiveness and operational suitability versus critical issues as well as the adequacy of testing to that point in the development of item or system.

INDEPENDENT TEST AGENCY - The Army Operational Test and Evaluation Agency, the Navy Operational Test and Evaluation Force, the Air Force Operational Test and Evaluation Center, and the Marine Corps Operational Test and Evaluation Agency.

INITIAL OPERATIONAL TEST AND EVALUATION - The first phase of operational test and evaluation conducted on preproduction items, prototypes, or pilot production items and normally completed prior to the first major production decision. It is conducted to provide a valid estimate of expected system operational effectiveness and suitability.

IN-PROCESS REVIEW - Review of a project or program at critical points to evaluate status and make recommendations to the decision authority. Conducted by the MATDEV.

ISSUES - Any aspect of the system's capability, either operational, technical, or other, that must be questioned before the system's overall military utility can be known. Operational issues are those that must be evaluated considering the soldier and the machine as an entity to estimate the operational effectiveness, and operational suitability of the system in its complete user environment.

JOINT DEVELOPMENT TESTS - JDT provides information on intraservice system or equipment requirements, performance, or interoperability; on technical concepts, requirements, or improvements; and on the improvement or development of testing methodologies or resources.

JOINT OPERATIONAL TESTS - JOT uses actual fielded equipment, simulators, or surrogate equipment in an exercise or operational environment to obtain data pertinent to interservice operational doctrine, tactics, and procedures.

LETHALITY - The probility that weapon effects will destroy the target or render it neutral.

LIFE-CYCLE COST - The total cost to the Government for the development, acquisition, operation and logistic support of a system or set of forces over a defined life span.

LOGISTICS SUPPORTABILITY - The degree of which the planned logistics support (including test equipment, measurement and diagnostic equipment, spares and repair parts, technical data, support facilities, transportation requirements, training and manpower) allow meeting system availability and wartime usage requirements.

LONG LEAD ITEMS - Those components of a system or piece of equipment that take the longest time to procure, and therefore, may require an early commitment of funds in order to meet acquisition program schedules.

LOW RATE INITIAL PRODUCTION - Any manufacture of a system in limited quantity to be used in OT&E for verification of production engineering and design maturity and to establish a production base.

MAINTAINABILITY - A characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

MAJOR DEFENSE ACQUISITION PROGRAM - As specified in 10 United Stated Code, Sections 136a and 139a (reference (l)) and DoD Directive 5000.1 (reference (m)).

a. A DoD acquisition program that is not a highly sensitive/classified program (as determined by the Secretary of Defense) and:

(1) That is designated by the Secretary of Defense as a major defense acquisition program; or

(2) That is estimated by the Secretary of Defense to require an eventual total expenditure for research, development, test and evaluation of more than 200 million dollars (based on fiscal year 1980 constant dollars) or an eventual total expenditure for procurement of more than 1 billion dollars (based on fiscal year 1980 constant dollars).

b. A DoD acquisition program that is designated jointly by the DOT&E and DDDRE(T&E), as a major defense acquisition program for the purpose of carrying out the responsibilities, functions, and authorities of this Manual. Such designation for the purpose of Test and Evaluation oversight does not imply any other related review requirements.

MAJOR RANGE AND TEST FACILITY BASE (MRTFB) - The complex of major DoD ranges and test facilities.

MILESTONE - A major management decision point in the overall acquisition process of a major DoD system requiring OSD and/or DoD Component program review. Milestones include both Joint Resource Management Board (DRB) and DoD Component equivalent Program Reviews.

MILITARY REQUIREMENT - An established need justifying the timely allocation of resources to achieve a capability to accomplish approved military objectives, missions, or tasks. Requirements are normally documented in a MSR, O&O Plan, LOA, ROC, LR, TDLR, TDR or SN-CIE.

MISSION AREA ANALYSIS - Continuous analysis of assigned mission responsibilities in the several mission areas to identify deficiencies in the current and projected capabilities to meet essential mission needs, and to identify opportunities for the enhancement of capability through more effective systems and less costly methods.

MISSION NEED STATEMENT - Submitted prior to POM submission. Approval by SECDEF is Milestone 0. Documents major mission deficiencies (or opportunities for improvement) in a service's ability to meet mission requirements when such deficiencies can be corrected by: (1) using an existing U.S. system or allied military or commercial system, (2) a major modification to an existing system, or (3) a new major acquisition. A joint MNS is prepared to document major deficiencies in two or more DoD components. OSD or OJCS may also prepare MNS.

MISSION RELIABILITY - The probability that the system will perform mission essential functions for a period of time under the conditions stated in the mission profile.

MODEL - A model is a representation of an actual or conceptual system that involves mathematics, logical expressions, or computer simulations that can be used to predict how the system might perform or survive under various conditions or in a range of hostile environment.

MULTISERVICE OPERATIONAL TEST - A form of test when one or more of the services provide support service test or vice versa, or tests that involve agreements between a service and one or more of the other services to evaluate a system or concept that requires testing in a multiservice environment.

NUCLEAR HARDNESS - A quantitative description of the physical attributes of the system or component that will allow nuclear survivability in a given weapon environment. Hardness is measured by physical quantities such as overpressure, peak velocities, energy absorbed, electrical stress, etc. Hardness is achieved through design specifications and often verified by one or more test and analysis techniques. Hardness is only one of several means of attaining system-wide nuclear survivability.

NONDEVELOPMENT ITEM (NDI) - Already developed and available hardware and/or software capable of fulfilling Service requirements, thereby minimizing or eliminating the need for costly, time-consuming Government-sponsored R&D programs. NDI is usually off-the-shelf or commercial-type products, but may also include equipment already developed by or for the military services or foreign military forces.

OPERATIONAL AVAILABILITY (Ao) - An index of a weapon system materiel readiness, including system software where applicable, in a mission environment. It is a measure of the probability of an item's being in a condition, generally referred to as "up", such that it can perform its intended function, within acceptable limits of degradation, when called upon.

OPERATIONAL EFFECTIVENESS - The overall degree of mission accomplishment of a system used by representative personnel in the context of the organization, doctrine, tactics, threat (including countermeasures and nuclear threats), and environment in the planned operational employment of the system.

OPERATIONAL EVALUATION - Addresses the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users and the system operational issues and criteria; provides information to estimate organizational structure, personnel requirements, doctrine, training and tactics; identifies any operational deficiencies and the need for any modifications; and assesses MANPRINT (safety, health hazards, human factors, manpower and personnel) aspects of the system, in a realistic operational environment.

OPERATIONAL REQUIREMENT (OR) - The basic requirement document for all Navy acquisition programs requiring research and development effort.

OPERATIONAL SUITABILITY - The degree to which a system can be placed satisfactorily in field use, with consideration being given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistic supportability, and training requirements.

OPERATIONAL TEST AND EVALUATION (OT&E) - The field test under realistic combat conditions, of any item (or key component of) weapons, equipment, or munitions for the purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users; and the evaluation of the results of such test.

OPERATIONAL TEST CRITERIA - Expressions of the operational level of performance required of the military system to demonstrate operational effectiveness for given functions during each operational test. The expression consists of the function addressed, the basis for comparison, the performance required, and the confidence level.

OPERATIONAL TEST READINESS REVIEW - A review to identify problems that may impact the conduct of an OT&E. OTRR's are conducted to determine changes required in planning, resources, or testing necessary to proceed with the OT-OTRR participants include the operational tester (chair), evaluator, material developer, user representative, logisticians, HQDA staff elements and others as necessary.

OPERATIONAL TEST - Testing of materiel systems that is accomplished with representative user operators, crews, support personnel, or units in as realistic an operational environment as possible to provide the evaluator data to estimate:

a. The military operational effectiveness, and operational suitability (including compatibility, interoperability, reliability, availability, and maintainability, supportability, operational soldier/hardware/software interface, and training requirements) of new systems.

b. The system's desirability, from the use viewpoint, considering systems already available and the operational benefits and/or burdens associated with the new system.

c. The need for modification to the system.

d. The adequacy of doctrine, organization, operating techniques, tactics, and training for employment of the system; the adequacy of maintenance and supply support for the system; the adequacy of maintenance and supply support for the system; and, when appropriate, its performance in a countermeasure environment.

PILOT PRODUCTION - The controlled manufacture of limited numbers of an item for service test and evaluation purposes using manufacturing drawings and specifications which have been developed for quantity production and with tooling that is representative of that to be used in unlimited production.

POST-PRODUCTION TESTING - Testing conducted to assure that materiel which is reworked, repaired, renovated, rebuilt, or overhauled after initial issue and deployment conforms to specified quality, reliability, safety, and operational performance standards. Included in post-production tests are surveillance tests, stockpile reliability, and reconditioning tests.

PREPLANNED PRODUCT IMPROVEMENT - Planned future evolutionary improvement of developmental systems for which design considerations are effected during development to enhance future application of projected technology. Includes improvements planned for ongoing systems that go beyond the current performance envelope to achieve a needed operational capability.

PREPRODUCTION PROTOTYPE - An article in final form employing standard parts, representative of articles to be produced on a production line with production tooling.

PREPRODUCTION QUALIFICATION TEST - The formal contractual tests that ensure design integrity over the specified operational and environmental range. These tests usually use prototype or preproduction hardware fabricated to the proposed production design specifications and drawings. Such tests include contractural reliability and maintainability demonstrations tests required prior to production release.

PRODUCT IMPROVEMENT PLAN (PIP) - Effort to incorporate a configuration change involving engineering and testing effort on end items and depot repairable components, or changes on other than developmental items to increase system or combat effectiveness or extend the useful military life.

PRODUCTION PROVE OUT TESTS - A technical test conducted post MS II or post MS I/II prior to production testing with prototype hardware. This testing provides data on safety, the achievability of critical system technical characteristics, refinement and ruggedization of hardware configurations, and determination of technical risks. After type classification, production prove out testing may also be conducted to provide data which could not be obtained prior to technical compliance, such as survivability or environmental. Program funding category - 6.4.

PRODUCTION QUALIFICATION TEST - A technical test conducted post-MS III to ensure the effectiveness of the manufacturing process, equipment and procedures. This testing also serves the purpose of providing data for the independent evaluation required for materiel release so that the evaluator can address the adequacy of the materiel with respect to the stated requirements. These tests are conducted on a number of samples taken at random from the first production lot, and are repeated if the process or design is changed significantly, and when a second or alternative source is brought on line. Program funding category - Procurement.

PROGRAM MANAGER - Individual chartered by the Service Secretary reporting to the material developer or to the commander of a subordinate organization as designated by the material developer. Assigned responsibility and delegated full-line authority of the material developer for centralized management of a specified acquisition or materiel readiness program. May be superimposed over one or more product managers.

QUALITY ASSURANCE - A planned and systematic pattern of all actions necessary to provide adequate confidence that materiel conforms to established technical requirements and achieves satisfactory performance in service.

QUALIFICATIONS TESTING - Which verifies the design and manufacturing process and provides a baseline for subsequent acceptance tests. The completion of Preproduction Qualification Test and Evaluation before MS III decisions is essential and will be a critical factor in assessing the system's readiness for production. Production Qualification T&E shall be conducted on production items.

RELIABILITY - The probability that an item will perform its intended function for a specified interval under stated conditions.

REALISTIC TEST ENVIRONMENT - The conditions under which a system is expected to be operated and maintained, including the natural weather and climatic conditions, terrain effects, battlefield disturbances, and enemy threat conditions.

REQUIRED OPERATIONAL CAPABILITY (ROC) - A brief statement of a specific operational capability which is required in the mid-range period.

RESEARCH (Budget Category 6.1) - Includes all effort of scientific study and experimentation directed toward (1) increasing knowledge and understanding in those fields of the physical, engineering, environmental and life sciences related to long-term national security needs. It provides fundamental knowledge required for the solution of military problems. It forms a part of the base for (a) subsequent exploratory and advanced developments in Defense-related technologies, and (b) new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support.

RISK - An expression of possible loss in terms of hazard severity and hazard probability.

RISK ASSESSMENT - An evaluation of a risk in terms of mission loss should a hazard result in an accident.

REQUIRED OPERATIONAL CHARACTERISTICS - Qualitative and quantitative system parameters approved by the user that are primary indicators of a system's capability to accomplish its mission (operational effectiveness) and to be supported (operational suitability).

REQUIRED TECHNICAL CHARACTERISTICS - Quantitative system parameters approved by the DoD Component that are selected as primary indicators of technical achievement of engineering thresholds. These might not be direct measures of, but should always relate to, a system's capability to perform its required mission function and to be supported.

SAFETY - Freedom from those conditions that can cause death, injury, occupational illness, or damage to, or loss of, equipment or property.

SAFETY/HEALTH VERIFICATION - The development of data used to evaluate the safety and health features of a system to determine its acceptability. This is done primarily during developmental test (DT) and user or operational test (OT) and evaluation and supplemented by analysis and independent evaluations.

SAFETY RELEASE - A formal document issued to a user test organization before any hands-on use or maintenance by personnel. The Safety Release indicates the system is safe for use and maintenance by typical user personnel and describes the system safety analyses. Operational limits and precautions are included. The test agency uses the data to integrate safety into test controls and procedures and to determine if the test objectives can be met within these limits.

SELECTED ACQUISITION REPORT - Standard, comprehensive, summary status report on DoD acquisition programs for management within DoD provided to Congress.

SIMULATION - A simulation is a method for implementing a model. it is the process of conducting experiments with a model for the purpose of understanding the behavior of the system modeled under selected conditions or limits imposed by developmental or operational criteria. Simulation may include the use of analog or digital devices, laboratory models, or "testbed" sites. Simulations are usually programmed for solution on a computer; however, in the broadest sense military exercises and wargames are also simulations.

SPECIFICATION - A specific quantitative, contractually binding, required operational or technical characteristic.

SUBTEST - An element of a test program. A subset is a test conducted for a specific purpose. (e.g., rain, dust, transportability, missile firing, fording).

SUITABILITY - A subjective determination by a decision authority that a materiel system does or does not meet minimum standards prerequisite to satisfy field service use. The judgement may be based on the presence or absence of uncorrectable materiel deficiencies, and/or the number and assessed importance of correctable and uncorrectable shortcomings. It also includes judgements on nonmateriel issues.

SURVIVABILITY - The capability of a system to avoid or withstand man-made hostile environments without suffering an abortive impairment of its ability to accomplish its designated mission.

SUSCEPTIBILITY - The degree to which a device, equipment, or weapon system is open to effective attack due to one or more inherent weaknesses. (Susceptibility is a function of operational tactics, countermeasures, probability of enemy fielding a threat, etc.).

SYSTEM - A composite, at any level of complexity, or personnel, procedures, materials, tools, equipment, facilities, and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific production, support, or mission requirement.

SYSTEM ENGINEERING, DEFENSE - That portion of the acquisition process dealing with the transformation of an operational need into an optimal set of system performance parameters and a preferred system configuration. It includes engineering/technical management, definition of system and program, design engineering, support engineering, the integration of the engineering specialties, and other such factors that affect the development, production, deployment, operation, and disposal of the system.

SYSTEM ENGINEERING PROCESS - A logical sequence of activities and decisions transforming an operational need into a description of system performance parameters and a preferred system configuration.

TECHNICAL EVALUATION - Addresses the system's technical issues and criteria and the acquisition and fielding of an effective, supportable, and safe system by assisting in the engineering design and development and verifying attainment of technical performance specifications, objectives, producibility, adequacy of the Technical Data Package, and supportability; determining safety, health hazards, human factors, and MANPRINT aspects. Technical evaluation encompasses the use of models, simulations, and testbeds, as well a prototypes or full-scale development models of the system.

TECHNICAL FEASIBILITY TEST - A technical test conducted post-MS 0, pre-MS I or MS I/II (under the Army Streamlined Acquisition Process) to assist in determining safety and establishing system performance specifications and feasibility.

TECHNICAL TESTER - The command or agency that plans, conducts, and reports the results of the Army technical testing. Associated contractors may perform development testing on behalf of the command or agency.

TECHNICAL TESTS - A generic term for testing which gathers technical data during the conduct of development testing, technical feasibility testing, qualification testing, joint development testing, and contractor/foreign testing. Soldier operator-maintainer test and evaluation personnel are used during the conduct of technical testing, when appropriate.

TEST CRITERIA - Standards by which test results and outcome are judged.

TEST AND EVALUATION MASTER PLAN - An overall test and evaluation plan, prepared as early as possible in the acquisition process, and is designed to identify and integrate objectives, responsibilities, resources, and schedule for all test and evaluation to be accomplished prior to key decision milestones.

TESTBEDS - A system representation consisting partially of actual hardware and partially of computer models or prototype hardware.

TEST INSTRUMENTATION - Test instrumentation is scientific, ADPE, or technical equipment used to measure, sense, record, transmit, process, or display data during tests, evaluations, or examination of materiel, training concepts, or tactical doctrine. Audio-visual is included as instrumentation when used to support Army testing.

TEST RESOURCES - A collective term that encompasses all elements necessary to plan, conduct and collect/analyze data from a test event or program. Elements include test funding and support manpower (including TDY costs), test assets (or, units under test), test asset support equipment, technical data, simulation models, testbeds, threat simulators, surrogates and replicas, special instrumentation peculiar to a given test asset or test event, targets, tracking and data acquisition, instrumentation, and equipment for data reduction, communications, meteorology, utilities, photography, calibration, security, recovery, maintenance and repair, frequency management and control, and base/facility support services.

TEST DESIGN PLAN - A statement of the conditions under which the test is to be conducted, the data required from the test, and the data handling required to relate the data results to the test conditions.

THREAT - The sum of the potential strength, capabilities, and intentions of an enemy which can limit or negate mission accomplishment or reduce force, system, or equipment effectiveness.

THRESHOLDS - The minimum level a system must meet (e.g. performance threshold of 30K ft. for a missile).

TRANSPORTABILITY - The inherent capability of materiel to be moved by towing, by self-propulsion, or by carrier via railways, highways, waterways, pipelines, ocean, and airways.

USER REPRESENTATIVE - The combat developer designated to represent the user during the materiel acquisition process. The command or agency fulfilling this role represents the " mission-oriented" user and the "logistics-oriented" user by concerning itself with both the operational and logistic support aspects of materiel system.

VULNERABILITY - The characteristics of a system that cause it to suffer a definite degradation (loss or reduction of capability to perform the designated mission) as a result of having been subjected to a certain (defined) level of effects in an unnatural (man-made) hostile environment.

WORK BREAKDOWN STRUCTURE - A product-oriented family tree division of hardware, software, services and other work tasks which organizes, defines and graphically displays the product to be produced as well as the work to be accomplished to achieve the specified product.

APPENDIX C
BIBLIOGRAPHY

DEPARTMENT OF DEFENSE DIRECTIVES

1. DoDD 3200.11, Major Range and Test Facility Base
2. DoDD 3200.11-D, Major Range and Test Facility Base Summary of Capabilities
3. DoDD 4245.6, Defense Production Management
4. DoDD 4245.7, Transition from Development to Production
5. DoDD 5000.1, Major and Non-Major Defense Acquisition Programs
6. DoDD 5000.3, Test and Evaluation
7. DoDD 5000.37, Acquisition and Distribution of Commercial Products
8. DoDD 5000.38, Production Readiness Reviews
9. DoDD 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment
10. DoDD 5010.8, Value Engineering Program
11. DoDD 5105.31, Defense Nuclear Agency
12. DoDD 5134.1, USD(A)
13. DoDD 5141.1, Director of Operational Test and Evaluation
14. DoDD 5160.5, Responsibilities for Research, Development, and Acquisition of Chemical Weapons and Chemical and Biological Defense

DEPARTMENT OF DEFENSE INSTRUCTIONS

15. DoDI 4245.4, Acquisition of Nuclear-Survivable Systems
16. DoDI 5000.2, Defense Acquisition Program Procedures
17. DoDI 5000.38, Production Readiness Reviews
18. DoDI 5030.55, Joint AEC-DoD Nuclear Weapons Development Procedures
19. DoDI 7000.10, Contractor Cost Performance

DEPARTMENT OF DEFENSE GUIDES/MANUALS

20. DoD 4145.7, Transition From Development to Production and Companion Manual, DoD 4245.7M

21.A. DoD 5000.3-M-1, Test and Evaluation Master Plan (TEMP) Guidelines

21.B. DoD 5000.3-M-2, Foreign Weapons Evaluation Program and NATO Comparative Test Program Procedures Manual

22. DoD 5000.3-M-3, Software Test and Evaluation ManuaL

DEPARTMENT OF DEFENSE STANDARDS

23. DoD-STD-2167, Defense System Software Development

24. DoD-STD-2168, Defense System Software Quality Program

MILITARY STANDARDS

25. MIL-STD-480, Configuration Control - Engineering Changes, Deviations, and Waivers

26. MIL-STD-483 (USAF), Configuration Management Practices for Systems, Equipment, Munitions, and Computer Software

27. MIL-STD-490, Specification Practices

28. MIL-STD-499A (USAF), Engineering Management Practices

29. MIL-STD-1388-1A, Logistic Support Analysis

30. MIL-STD-1512A, Technical Reviews and Audits for Systems, Equipment, and Computer Programs

31. MIL-STD-1528, Manufacturing Master Plan

MILITARY HANDBOOKS

32. Joint Test Director's Handbook (Draft)

OTHER MILITARY DOCUMENTS

33. Test and Evaluation in the United States Department of Defense, Office of the Under Secretary of Defense for Research and Engineering (Director Defense Test and Evaluation), August 1983.

34. Statement by Mr. James F. O'Bryon, Assistant Deputy Under Secretary of Defense (Live Fire Test) Before the Acquisition Policy Panel of the House Armed Services Committee, September 10, 1987

35. Memorandum of Agreement of Multi-Service OT&E and Joint T&E, with Changes

36. Joint Test and Evaluation Procedures Manual, (Draft), Office of the Deputy Under Secretary for Research and Engineering (Test and Evaluation), October 1986

37. Live Fire Test and Evaluation Guidelines, Office of the Assistant Deputy Under Secretary of Defense (Live Fire Test), May 7, 1987

38. Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C^2) Systems, Defense Systems Management College, March 1987

39. Concept and Approach for a Joint Test and Evaluation of U.S. Chemical Warfare Retaliatory Capabilities, JCHEM Joint Test Force, AD #B088340, February 1984

40. FY88 Report of the Secretary of Defense to the Congress

41. Report of Task Force on Test and Evaluation, Defense Science Board, April 1, 1974

42. Solving the Risk Equation in Transitioning from Development to Production, Defense Science Board Task Force Report, May 25, 1983. (later published as DoD Manual 4245.7

43. Risk Management as a Means of Direction and Control, Program Manager's Notebook, Fact Sheet Number 6.1, DSMC, April 1985

44. Joint Logistics Commanders Guide for the Management of Joint Service Programs, DSMC, June 1982

45. Systems Engineering Management Guide, Second Edition, DSMC, December 1986.

46. Integrated Logistics Support Guide, First Edition, DSMC, May 1986

47. Joint Logistics Commanders Guide for the Management of Multinational Programs, DSMC, July 1981

48. Defense Manufacturing Management Course, DSMC

49. DVAL Metholodology -- Methodology Overview/Executive Summary, Data Link Vulnerability Analysis Joint Test Force, November 1984

ARMY DOCUMENTS

50. AR 10-4, U.S. Army Operational Test and Evaluation Agency

51. AR 10-11, U.S. Army Material Development and Readiness Command

52. AR 10-41, U.S. Army Training and Doctrine Command

53. AR 10-42, U.S. Armed Forces Command

54. AR 70-10, Research, Development, and Acquisition Test and Evaluation

55. AR 70-24, Special Procedures Pertaining to Nuclear Weapons System Development

56. AR 70-60, Nuclear Survivability of Army Materiel

57. AR 70-71, Nuclear, Biological, and Chemical Contamination Survivability of Army Material

58. AR 71-1, System Acquisition Policy and Procedures

59. AR 71-3, Force Development User Testing

60. AR 700-127, Integrated Logistic Support

61. DA PAM 71-3, Force Development Operational Test and Evaluation Methodology and Procedures Guide

62. DA PAM 71-3, Annex G (Draft), Mission Performance

63. DA PAM 700-50, Integrated Logistic Support: Developmental Supportability Test and Evaluation Guide

64. AMC PAM 70-2, AMC-TRADOC Materiel Acquisition Handbook

65. TECOM PAM 310-4, Index of Test Operations Procedures and International Test Operations Procedures

66. USAOTEA Operational Test and Evaluation Guide, Special Supplement, Continuous Comprehensive Evaluation Planning for Nuclear Hardness and Survivability Test and Evaluation (Draft)

NAVY DOCUMENTS

67. SECNAVINST 5000.1B, System Acquisition

68. SECNAVINST 5000.39, USN Acquisition and Management of ILS for Systems and Equipment

69. SECNAVINST 5000.42C, RDT&E Acquisition Procedures

70. SECNAVINST 5430.67A, Assignment of Responsibilities for Research, Development, Test and Evaluation

71. OPNAVINST 3070.1A, Operations Security

72. OPNAVINST 3960.10C, Test and Evaluation (Draft)

73. OPNAVINST 5000.49, ILS in the Acquisition Process

74. OPNAVINST 5440.47F, Mission and Functions of Operational Test and Evaluation Force (OPTEVFOR)

75. NAVMATINST 3960, Test and Evaluation

76. COMOPTEVFORINST 3960.1D, Operational Test Director's Guide

77. NAVSO P-2457, RDT&E/Acquisition Management Guide, 10th Edition

78. COMOPTEVFOR, Project Analysis Guide

79. COMOPTEVFOR, AD Number AD124168, Operational Test Director Guide

AIR FORCE DOCUMENTS

81. AFR 23-36, Air Force Operational Test and Evaluation Center (AFOTEC)

82. AFR 55-30, Operations Security

83. AFR 55-43, Management of Operational Test and Evaluation

84. AFR 80-14, Test and Evaluation

85. AFR 80-38, Management of the Air Force Systems Survivability Program

86. AFR 800-2, Acquisition Program Management

87. AFR 800-8, Integrated Logistic Support (ILS) Program

88. CAFSCR 550-15, Statistical Process Control

89. AFSCR 550-13, Producibility

90. AFOTEC Regulation 23-1, Organization and Functions Air Force Operational Test and Evaluation Center (AFOTEC)

91. AFOTEC, Nuclear Survivability Handbook for Air Force OT&E

92. AFOTEC, Electronic Warfare Operational Test and Evaluation

93. AFLC Pamphlet 800-34, ACQ Logistic Management

94. Rome Air Development Center, Standard Procedures for Air Force Operational Test and Evaluation

MARINE CORPS DOCUMENTS

95. MCO 3960.2, Marine Corps Operational Test and Evaluation Activity (MCOTEA); establishment of, with changes
96. MCO 5000.11A, Testing and Evaluation of Systems and Equipment for the Marine Corps

OTHER GOVERNMENT DOCUMENTS

97. Public Law 99-661, National Defense Authorization Act for Fiscal Year 1987

98. Public Law 92-156

99. Public Law 98-94

100. GAO/PEMD-87-17, Live Fire Testing: Evaluating DoD's Programs

101. GAO/NSIAD-87-57, Operational Test and Evaluation Can Contribute More to Decision-Making

102. GAO/PEMD-86-12BR, Bigeye Bomb: An Evaluation of DoD'S Chemical and Developmental Tests

103. GAO/PSAD-79-86, Review of Military Services Development Test and Evaluation of Six Weapon Systems Totalling an Estimated $12 Billion in Development and Procurement Costs

104. GAO/PSAD-78-102, Operational Testing of Air Force Systems Requires Several Improvements

105. Memorandum of Understanding Among the Governments of the French Republic, the Federal Republic of Germany, the United Kingdom of Great Britain and Northern Ireland, and the United States of America Relating to the Mutual Acceptance of Test and Evaluation for the Reciprocal Procurement of Defense Equipment

106. Director, Defense Test and Evaluation Memorandum of August 2, 1983; Response of Admiral Isham Linder, Director, Test and Evaluation to Supplemental Questions Posed by the Senate Governmental Affairs Committee

107. Hearing Before the Senate Committee on Governmental Affairs, June 23, 1983

OTHER REFERENCES

108. Anderson, J.E., "Towards the Goal of Improving MIL-STD Testing," Defense Systems Management Journal, Vol. 12, Number 2, pages 30-34, April 1976

109. The BDM Corporation, "Application of Simulations to the OT&E Process," May 1974

110. Bolino, John V., "Software T&E in the Department of Defense"

111. The BDM Corporation, "Functional Description of the Acquisition Test and Evaluation Process," July 8, 1983

112. Hoivik, Thomas H., "The Navy Test and Evaluation Process in Major Systems Acquisition," DTIC Accession Number AD A035935, November 1976

113. Johnson, Larry H., "Contractor Testing and the Army Test and Evaluation Master Plan for Full Engineering Development", Defense Systems Management College, November 1977

114. Rhoads, D.I., "Systems Engineering Guide for Management of Software Acquisition," pages IV-1 through IV-23, Defense Systems Management College, Ft. Belvoir, Virginia, 1983

115. The MITRE Corporation, "Software Reporting Metrics," November 1985

116. Stevens, Roger T., John Wiley & Sons, New York, "Operational Test and Evaluation: A Systems Engineering Process," 1979, pp 49-56

117. International Test and Evaluation Association, "Test and Evaluation of Command and Control Systems Developed by Evolutionary Acquisition," May 1987

118. Mann, Greg A., LTC, Air University Press, Maxwell AFB, AL, "The Role of Simulation in Operational Test and Evaluation," Report AU-ARI-83-10; August 1983

119. Georgia Institute of Technology, "The Software Test and Evaluation Project"

120. Thomas, E. F., "Reliability Testing Pitfalls," Reliability and Maintainability Symposium, Vol. 7, Number 2, pages 78-85, 1974

121. Watt, Charles K., "The Role of Test Beds in C^3I," AFCEA 36th Annual Convention, 15-17 June 1982.

122. Willoughby, Willis J., "Reliability by Design, Not Chance," Defense Systems Management Journal, Vol. 12, Number 2, pages 12-18, April 1976

INDEX

APPENDIX D
POINTS OF CONTACT
SERVICE TEST & EVALUATION COURSES

ARMY

Commander U.S. Army Test and Evaluation Command
ATTN: AMSTE-TE
Aberdeen Proving Ground, Maryland 21005-5055

Commander U.S. Army Logistics Management College
ATTN: AMXMC-ACM-MA
Ft. Lee, Virginia 23801-6048

Commander U.S. Army Operational Test & Evaluation Agency
ATTN: CSTE-PO
5600 Columbia Pike
Falls Church, Virginia 22041-5115

NAVY

Commander Space & Naval Warfare Systems Command
ATTN: Management Operations
National Center, Bldg. 1
Washington, D.C. 20361

Commander Operational Test & Eval ation Force
ATTN: Dest 02B
Norfolk, Virginia 23511-6388

AIR FORCE

Commander Air Force Operational Test and Evaluation Center
ATTN: Asst. Director, Training
Building 20130
Kirtland Air Force Base, New Mexico 87117-7001

Commander Air Force Institute of Technology
ATTN: Student Operations
Wright-Patterson Air Force Base, Ohio 45433

☆ U.S. GOVERNMENT PRINTING OFFICE: 1989— 242 - 472 /03841

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION BDM Corporation 6b. OFFICE SYMBOL *(If applicable)*	7a. NAME OF MONITORING ORGANIZATION Defense Systems Management College
6c. ADDRESS *(City, State, and ZIP Code)* 7915 Jones Branch Drive McLean, VA 22102-3396	7b. ADDRESS *(City, State, and ZIP Code)* DSMC-SE-T Ft Belvoir, VA 22060-5426
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL *(If applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-87-C-0046
8c. ADDRESS *(City, State, and ZIP Code)*	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. 0004AA / WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*

Test and Evaluation Management Guide (U)

12. PERSONAL AUTHOR(S)

Stuart K. Purks, Jacqueline C. Hamilton

13a. TYPE OF REPORT	13b. TIME COVERED FROM ____ TO ____	14. DATE OF REPORT *(Year, Month, Day)*	15. PAGE COUNT
		88 March 18	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*

Test and Evaluation, Development Test, Operational Test, Test Management, Test, Evaluation

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Department of Defense policy requires that Program Managers develop and manage a testing program for the system under development which includes both the development and operational testing nesessary to measure system performance against predetermined thresholds and goals. The data developed during various testing activities supports evaluations by the contractor or government development tester and the independent operational test agency. These evaluations or assessments are used to support the decision making process during management reviews of Systems Risks, Technical Compliance and Operational Performance.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE *(Include Area Code)* / 22c. OFFICE SYMBOL

Comment Sheet
for
Test and Evaluation Management Guide

This guide was prepared as a reference document for program management personnel. Because of ongoing research in the area of test and evaluation and the dynamic nature of the entire acquisition process, revisions, additions and updates to this book are expected to be necessary. Your comments and suggestions are solicited.

If you have comments, please tear this sheet out, write the comments in the space provided below, fold, tape closed, and mail. This form is pre-addressed and needs no postage.

Comment:

Name/Title ______________________________

Address ______________________________

____

Telephone (Commercial) __________ **(AUTOVON)** __________ **(FTS)** __________

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO.12062 FORT BELVOIR, VA

POSTAGE WILL BE PAID BY ADDRESSEE

Defense Systems Management College
Attn: DRI-P
Fort Belvoir, VA 22060-9989